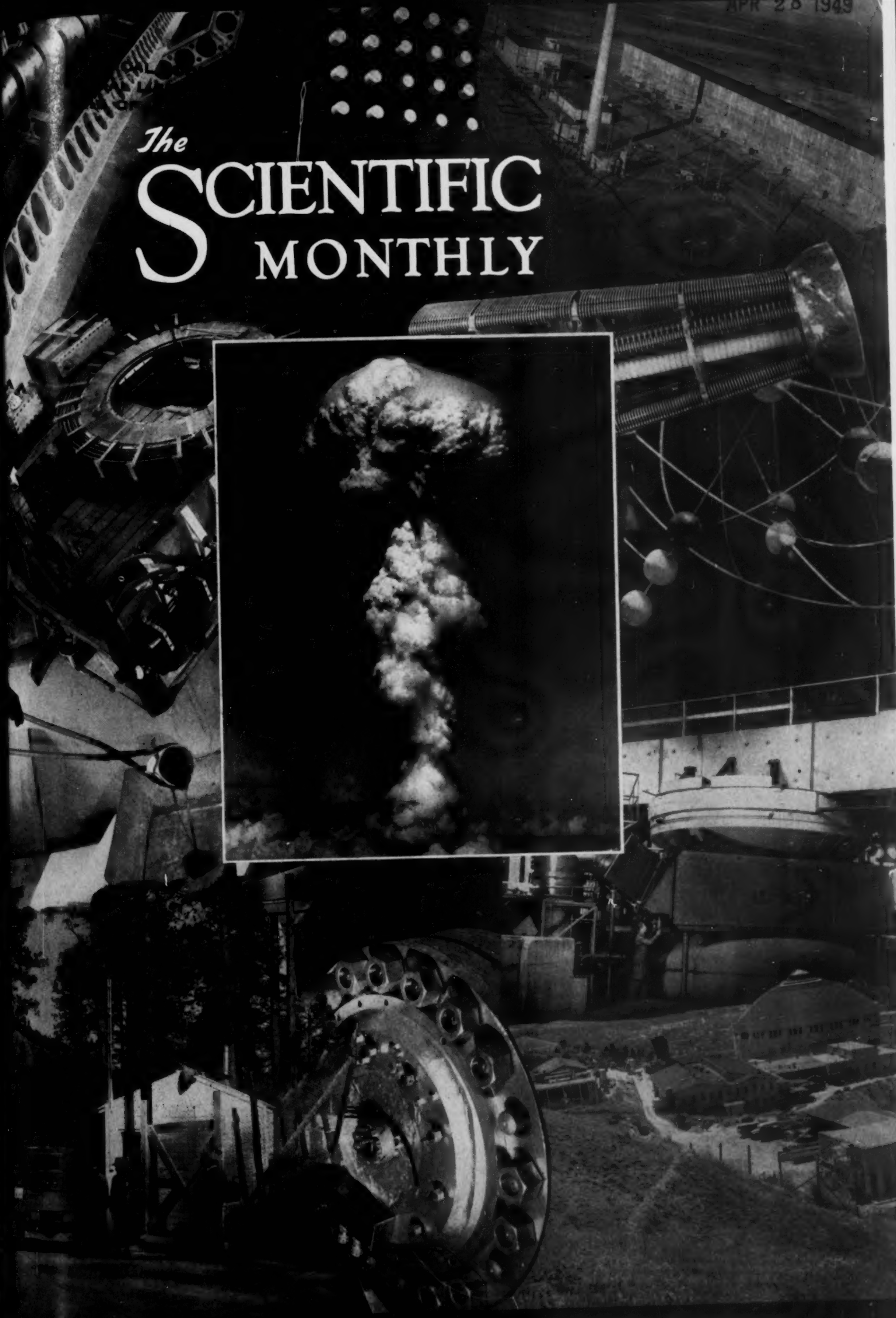
The SCIENTIFIC MONTHLY



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Annual Book Issue

(Cover photos by courtesy of the Atomic Energy Commission)

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Science and Technology

(From the Month's News Releases)

Ears and Nose of Science

A plastic nose and a robot ear were recently exhibited at a meeting of the American Medical Association. The nose, named pneophore, is a small gadget to replace the iron lung for some uses. Developed originally for miners, it has been employed in infantile paralysis, drowning, overdoses of sleeping pills, premature deliveries, asthma, etc.

The robot ear is a salt crystal in a box below a telephone. Vibration, caused by the ringing of the phone, makes electricity flow in the salt, the current is amplified to turn on a light switch, and a sleepy doctor can answer his midnight phone call without fumbling or stumbling. The ear can also be used to turn on the porch light. When the householder gets ready to return home, he simply calls his house and the ear turns on the light.

Safety Step

Ordinary ladders can be turned into safety ladders with comfortable footing by means of the Safety Tread Ladderstep invented by the Agricola brothers, of the Saginaw Bearing Company. The device is a simple, lightweight, attachable platform of hardwood, equipped with "Safety-Walk" tread. It is adjustable to maintain a horizontal plane, no matter what the incline angle of the ladder, and frees both hands for the job. Another model is in preparation to fit the new metal-rung ladders, which differ from the standard.

Wood Fastener

A new product called Chair-Loc is on the market for tightening loose chair rungs, loose hammer handles, and the like. The manufacturers say that "by swelling the wood fibers in a wood or wood and metal socket, the wood itself does the holding. . . . Chair-Loc swells the individual wood fiber. It then deposits a solid in the expanded fiber so that it retains its newly enlarged shape." Chair-Loc is offered for carpentry, kitchen, workbench, and garden use.

New Uses for Glass

A new electrically conductive coating for glass, thin and transparent but extremely tough and tenacious, has been developed, according to Dr. Robert H. Dalton, of the Corning Glass Works. An electric current passing through such a coating will generate heat just as electricity heats the coils of an iron or stove. The new coating may be applied to radiant heaters, glass coffee makers (to be used without other source of heat), heat interchangers, and defrosters.

Pictures that appear to be three-dimensional can now be developed in a special type of glass containing particles of gold and other metals so fine as to be invisible under an ordinary microscope, Dr. Dalton reports. Color prints of negatives can be made to last without fading as long as the glass itself. After ten minutes' exposure with an average negative, the glass must be baked at 600°–700° C for 20 minutes to an hour to develop the picture.

By dissolving part of the materials, a new type of glass with a network of extremely fine pores can be made into filters for viruses or to absorb fine dust.

Portable Television

A new lightweight portable television set equipped with a standard 7-inch tube has been designed for use in and out of doors and for easy transportation. The set weighs only 33 pounds and is 18 inches deep, 17¼ inches wide, and 9½ inches high. To operate the set, the removable, hinged lid is opened and the collapsible aerial is extended and fitted into a jack on the top of the unit. The set works with standard house current and has a 26-inch viewing field. The aerial can be turned to obtain maximum signal strength from different stations.

More Useful Plastics

Common plastics can now be heatproofed to approach the hardness of glass at high temperatures, reports Professor Herman F. Mark, of the Brooklyn Polytechnic Institute. Polystyrene has been reinforced with chlorine or nitrogen atoms to produce a material having almost the same excellent electrical insulation properties as polystyrene itself and retaining hardness up to 160° C. When polyethylene was similarly treated, the softening point rose from 100° to 250°, thus making possible the manufacture of an almost incredible number of useful things from these polymers in the pure and plasticized state.

Turning to synthetic fibers, Dr. Mark called them "distinctly superior in most qualities to their natural counterparts, the only unsolved problem at present being a synthetic material of wool-like character with high tensile strength and good resistance against atmospheric influence and molds."

Paint Progress

Zinc dust paint to protect galvanized steel; fume-proof paint for general house use; and fluorescent pigments for wall paintings to serve as both decoration and room illumination are finding increasing use in industry, homes, and elsewhere, according to the magazine *Paint Progress*. Fluorescent painting must be done under black light, and the fluorescent paints must be mixed with identical conventional colors so that the painting will be visible under ordinary light as well.

To help house painters duplicate any desired color by mixing only two or three paints, a "Color Coordinator" has been devised. The "Color Coordinator" is a pentagon-shaped chart on which a series of color chips is laid out in circles, rectangles, and triangles. When a color is selected, the painter merely mixes the two or three colors surrounding the specified shade, ending up with the correct color.

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MAY 1949

THE LITERATURE OF ATOMIC ENERGY OF THE PAST DECADE

H. H. GOLDSMITH

Mr. Goldsmith is head of the Information and Publication Division of Brookhaven National Laboratory. One of the earliest workers in neutron physics at Columbia University, he was, during the war, coordinator of Information in Physics at the Metallurgical Laboratory, University of Chicago. He is co-editor of the Bulletin of Atomic Scientists *and senior consultant of the U. N. Atomic Energy Commission. He is also a member of the National Research Council Committee on Nuclear Science and chairman of its Subcommittee on Publication and Information.*

THE study of atomic energy spans half a century. During the first four decades its literature pictured a normal, active branch of modern science. In the past decade, however, nuclear science exhibits the most curious mélange of writings and silences in the history of science. For it was during this period that the swift transformation of the discovery of nuclear fission into the most fearsome of weapons coincided with the most devastating war of our era.

Even in its earlier "normal" phase, the literature of nuclear science was distinguished by its variety and rapid growth. On the one hand, it included the highly abstruse treatment of some of the fundamental intellectual problems of twentieth-century science, the establishment of the nuclear model of the atom, the analysis of the structure of atomic nuclei, the prediction and discovery of the elementary particles within the nuclei, and the study of the strange, powerful forces exerted between these fundamental particles. On the other hand, the literature mirrored a tumultuous growth in the minutiae of experiments—the details of the properties of the hundreds of individual nuclei, and the techniques ranging from setups reminiscent of sealing wax and string to the gargantuan gadgets of the most ingenious of modern engineers. It was the interaction of these typical aspects of science that resulted in the remarkable growth culminating in the thirties.

During the decade preceding the war, certainly in the field of physics, the study of the atomic nucleus had become the preoccupation of the majority of research workers. A mere glance at the *Physical Review* reveals the startling shift from the studies in atomic spectroscopy in the twenties, to the investigations of atomic nuclei in the thirties. The immense bulk of publications in this field is seen from the fact that about 15,000 titles are included in a bibliography on atomic energy recently issued under the auspices of the United Nations. This bibliography makes no claim of completeness; probably at least twice this number of papers have been published on the atomic nucleus and closely related topics. Of these, perhaps 20,000 have been published during the second quarter of the century.

The rich variety of subject matter of interest to the nuclear scientist may be seen from a glance at the table of contents of this bibliography. The classical branches of the field—natural radioactivity, mass spectroscopy, the effect of high-energy radiations on biological systems, the beginnings of tracer techniques—gradually merge into the exciting disclosures of the prewar decade. It is in the

thirties that the journals become crammed with the many significant discoveries from which are fashioned our present concepts of the atomic nucleus: the discovery of the neutron, the deuteron, the positron, and the meson; the detailed study of the products of the transmutation of all the nuclei; the disclosure of artificial radioactivity; the determination of the angular momenta of the nucleus by means of molecular beams; the unraveling of cosmic-ray phenomena. A mere listing tells the story.

The fission of the atomic nucleus ranked high among these discoveries. The swift succession of publications in early 1939, the many examples of practically simultaneous disclosure of the same phenomenon, reflect the excitement of the scientific worker of the period. Despite this burst of publication, there grew in the minds of more and more nuclear scientists a realization of the serious military consequences of nuclear fission, and this realization soon led to a radically different attitude toward the publication of scientific results in this field.

There exists no detailed documentation from which we can accurately reconstruct the events and thoughts of the beginnings of the atomic-bomb projects, and of the secret literature of atomic energy. Our sources for the work in the United States are the brief treatment of the early period in Smyth's official report, and the memories of some of the leading participants of this period. For the work in Germany there is no official story available with even as much detail as is given by the Smyth Report. But the prewar scientific literature, Goudsmit's book *Alsos,* and a postwar article by Heisenberg in *Naturwissenschaften,* permit us to discern at least the main features of the period.

What is striking is the similarity in the treatment of the publication problem in both countries. In Germany, within a few months of the discovery of fission, some of the more important nuclear physicists had formed a secret, unofficial society—the Uranium Club. One might, naïvely, expect that publications in this subject would cease abruptly. This was not so. The investigations by Hahn and Strassmann of the chemical nature and radioactive properties of the fission products continued to be published throughout the entire war. A moderate number of papers on other aspects of the fission process appeared in apparently normal fashion in the usual journals. To a casual reader, although the German journals of the war period were issued in an increasingly irregular fashion, the treatment of nuclear science seemed to be a continuation of prewar publications. The decrease in the number of papers in the subject, it could be reasoned, was the natural consequence of the diversion of the nuclear scientists from this field to problems of greater practical military importance.

A more careful scrutiny of the journals revealed, however, that all the published material was of the same peripheral nature as fission-product chemistry, and that central practical problems like the chain reaction were not discussed at all. We now know that this omission was not due to a lack of research in these topics, but rather to a suppression of publication of the results of research. The discussions and investigations of groups like the Uranium Club were not published in the pages of *Naturwissenschaften* or the *Zeitschrift fur Physik.* They were initially reproduced in a very small number of copies for the exclusive use of members. A few months later, when Germany marched into Poland, the scientists presented their conclusions to government officials. Thereafter, their secret reports were handled in a more official and bureaucratic fashion. (The individual technical reports of the various German atomic-bomb projects have never been published in this country. A detailed technical summary of the reports has been prepared in the FIAT series under the auspices of the U. S. military authorities by the leading German nuclear scientists of the projects, but this has not yet been released in this country.)

A similar pattern of free publication of innocuous facts and the concomitant suppression of the more practical results concerned with nuclear fission is exhibited in the United States. It should be recalled that three years, instead of one, elapsed between the discovery of fission and our official entry into the war. Furthermore, an influential group of American scientists was frankly skeptical of the early claims by Szilard, Fermi, and Wigner that nuclear fission might play a practical role in the immediate future. Consequently, in early 1939, there was considerable resistance to the suggestion that this new, exciting academic field of research be placed immediately on a wartime basis with large-scale governmental support, and complete suppression of publication. It took the constant and imaginative prodding by the *émigré* nuclear scientists, led by Szilard, to alter these views.

Early in 1939, Szilard initiated a bold, unconventional attempt to establish a voluntary international censorship by all workers in nuclear fission outside Germany. Although the prestige of Niels Bohr was enlisted in this venture, lack of

cooperation by the French quashed the project. But this abortive attempt was fruitful in its educational effect on American scientists and editors. In the spring of 1940, almost two years before Pearl Harbor, a voluntary national censorship was successfully established by the scientists of this country. It was set up under the auspices of the National Research Council as a Reference Committee to control publication policy in all fields of military interest. If an editor of a scientific journal questioned the advisability of publishing a paper in nuclear science, the paper was referred to a small group of nuclear scientists constituting a subcommittee of the Reference Committee. Their completely unofficial decision was universally accepted by all the authors.

Of course, the pages of the *Physical Review* during most of 1940 and 1941 still presented a picture of lively activity in nuclear science. This activity was more apparent than real. Some of these papers represented early work which had been delayed in publication; others were reports of the final researches in the field by nuclear physicists who were already shifting to war work on radar; and a number of the papers on fission were from scientists in other countries—Japan, Denmark, Italy, Russia.

Behind the façade of normal publication was the growing mass of memoranda and technical papers describing the early secret work which was performed, first under the Advisory Committee on Uranium appointed, in the fall of 1939, by President Roosevelt, and, later, after June 1940, under the auspices of the NDRC. These secret reports were, in some cases, a continuation and refinement of the *Physical Review* articles of 1939. They dealt with the measurements of the neutron cross sections of uranium, the determination of the number of neutrons emitted in the fission process, and the study of the radioactive properties of various fission products. Most of the reports, however, described new concepts and strange setups, the exponential experiment for determining the multiplication constant, the lattice structure (or pile) of uranium and graphite, the detailed methods of separating the uranium isotopes, and the chemical, radioactive, and fission properties of neptunium and plutonium.

As the ramifications of the projects grew, and emphasis shifted to the combined scientific and large-scale engineering stage, the control of technical publication became much more formal. A policy of "compartmentation" soon emerged. This was based on the concept that the construction of the atomic bomb was the culmination of the separate but coordinated efforts of a large number of widely dispersed teams or projects. A member of a given team, it was assumed, could successfully complete his specific task without information concerning the work on the other projects. Thus, a person working on the problem of the chain-reacting pile to produce plutonium need not even know of the existence, much less the details of, the gaseous diffusion project for separating U-235. Nor did a member of the latter project have to be told about alternative schemes of separating U-235, such as the electromagnetic or the thermal diffusion methods. Further, a scientist on any of the above four projects could be valuable within his project without knowing anything about Los Alamos, where the construction of the bomb was being studied. Even within his own project, a scientist in one branch, say, biology, did not have access to all the results in some other branch, say, physics.

In effect, scientific publications were placed in separate compartments. At Chicago, for instance, within the Metallurgical Project (the scientific center of the project to manufacture plutonium), reports in physics were placed in series labeled "CP," and a report was usually identified by its number in this series, "CP516," or "CP2540," etc. Similarly, chemistry reports made up the series "CC——," biology and health reports, the series "CH——." On employment at the Metallurgical Project, a physicist was given access to reports in the "CP" series and, depending on his specific task, to a few peripheral categories. Under ordinary circumstances, he would not be permitted access to all the reports issued from the Metallurgical Project. Nor would he normally see any reports of the scientific work done on the separation of isotopes, or those concerned with the production plants at Oak Ridge and Hanford, or with the research and development work on the weapon.

Naturally, there was occasional official and unofficial relaxation of the strict application of compartmentation. After a scientist had become something of a veteran on the project, he was granted access to a sufficient number of subject categories, or to enough specific reports, to permit his functioning in a tolerable fashion. Some scientists, who were merely interested in their special subjects, even functioned in a quite normal manner. Further, the senior scientists, in time, obtained a complete understanding of their own project and, in outline, knowledge of the objectives of the other projects, with some inkling of the current stage of

progress toward these objectives. Even a junior scientist, on occasion, required information ordinarily stored in distant compartments; in such cases, his scientific superior, or the responsible administrator, permitted him a brief glance into some hitherto forbidden reports. Further breaks in compartmentation occurred with the rare shifts of personnel from one site to another. Thus, toward the end of the war, a sizable scientific group from the Metallurgical Project, having completed its assignments with the successful operation of Hanford, was transferred to Los Alamos, to aid in the final stages of the work on the bomb.

A by-product of secrecy and compartmentation was the change in some of the normal traditions of publication. So few scientists were permitted to read a given report that there was no need for more than about one hundred copies of any report. Most of the copies remained on the site of origin to be read by the workers in the original and in some of its neighboring compartments. The rest went to civilian and military administrators, leading scientists at other sites, and to a few central repositories where they could be read only by running a gantlet of compartmentation rules. Coupling the wartime emphasis on speed with the small number of required copies, there seemed to be little reason for the better methods of reproduction. Consequently, the average report was reproduced in slovenly fashion by Ditto or Mimeograph machines.

More important than these features of reproduction and distribution was the fact that the writing and editing of the report bore little resemblance to normal practices. A scientist is traditionally meticulous in the presentation of his paper in journals that are to be read by his colleagues and by later generations of scientists. If the quality of writing of a particular article is poor, editors enforce revisions. During the war, however, even the scrupulous among the scientists often wrote sketchy or poorly organized reports. As a result, information was irretrievably lost—information which was familiar to the small group who performed the experiments or the calculations, but which was not effectively transmitted to others. In the opinion of many scientists, their results were often crude approximations of the polished quality of the prewar work; hence, the description of these results, they felt, did not warrant polishing. Also, they realized that their reports were read mainly by a small group of equally harried colleagues. Under such circumstances, attempts at editorial revision were, to say the least, inadvisable.

Within a brief two or three years, the twin policies of secrecy and compartmentation wrought a startling change from the free international exchange of information of prewar days. If a scientist lived outside of Germany, the United States, England, or Canada, he was not aware of any substantial progress in nuclear science. Within these few countries, only those scientists employed on the secret atomic bomb projects were permitted access to the results of wartime researches; even for this select group, compartmentation reduced the amount of information made available to any individual.

In this country, the prewar nuclear physicist, whether he worked on some secret weapon, such as radar or the proximity fuse, or whether he remained at his teaching post, was not able to participate in the formulation and solution of such problems as diffusion theory, the construction of piles, the discovery of the transuranic elements and their isotopes, the accurate measurement of neutron cross sections, the details of the fission process, and the other branches of the field which were initiated or radically transformed behind the curtain of secrecy. In effect, this hiatus in their own research and the lack of access to the results of the research of others produced a "have-not" class from a group of former "haves." As a corollary, the scientists within the projects, whether old-timers or youngsters, obtained a temporary monopoly on the concepts and techniques in this field, a monopoly maintained as long as normal publication remained suspended.

The effect of this monopoly on the professional lives of individual scientists is, of course, trivial compared to its consequences for the well-being of nuclear science in our country. For secrecy is two-edged. It means withholding information from potential or actual enemies of our country. But it also means that the vast majority of physicists, chemists, biologists, engineers, and industrialists in this country are kept in ignorance of the advances in their special fields, and are thus prevented from the participation necessary for our own maximum progress.

After the disclosure of the bomb at Hiroshima and Nagasaki, and the termination of the war, it was clear that the maintenance of complete secrecy was neither possible nor desirable. Information had to be released to the people of the United States, to its scientists, engineers, and industrialists, to its congressmen, and to the peoples and political leaders of other countries. Some of this information was published almost immediately, partly in the form of announcements by high gov-

ernment officials, but mainly through the publication of the Smyth Report—*Atomic Energy for Military Purposes—The Official Report on the Development of the Atomic Bomb under the Auspices of the United States Government 1940–1945.*

The Smyth Report is still the most comprehensive single volume describing the work of the atomic-bomb projects during the war years. It made no pretense at being a complete account of the technical problems and their solutions; no details of the production plants or of bomb construction are presented; of the various scientific phases of the program, only some are treated, and these in general terms. It was, however, the first publication following a long silence, and because it gave a coherent over-all picture of the objectives and of the vast extent of the projects, the initial effect of the Smyth Report was startling even to the compartmentalized project scientists.

For about a year, the Smyth Report remained the only major technical publication in the field of nuclear science. Further publication awaited the study and establishment of criteria for releasing or withholding nuclear information. By 1946, the first formal statements of these criteria were embodied in two documents, the Atomic Energy Act and the Declassification Guide. The Act declares that the Atomic Energy Commission must "control the dissemination of restricted data in such a manner to assure the common defense and security." The term "restricted data" is defined as all data "concerning the manufacture or utilization of atomic weapons, the production of fissionable material, or the use of fissionable material in the production of power, but shall not include any data which the Commission from time to time determines may be published without adversely affecting the common defense and security."

Any broad, legal definition of "restricted data" must perforce be ambiguous, and no inflexible definition, even if originally precise, can keep pace with new discoveries. In practice, the interpretation of the term "restricted data" must be made by the Atomic Energy Commission. Not only does it administer the Act, but, in its intimate contacts with scientists, it is in the best position to devise flexible and practical solutions to the problems of secrecy and publication.

When it took office, the Commission inherited a set of rules and an administrative structure by which it could decide which information to withhold and which could be released for publication. These rules were originally laid down by the Tolman Committee, which included some of the leading project scientists, and were then formalized as a Declassification Guide. At present, the Guide, which has already undergone two revisions, lists more than fifty topics which must remain secret, and a like number of categories about which information can be released.

If the author of a technical report, or an official of his institution, wished to have his paper released for publication, it was submitted to a hierarchy of reviewers who rendered a decision based on the rules of the Declassification Guide. By applying this procedure to individual papers over the course of the past three years, almost 3,000 technical reports have now been "declassified." A goodly fraction of these reports have been submitted to, and accepted by, the scientific journals; the rest are being made available for sale as separate reports, or are being collected for publication in the volumes of the projected "National Nuclear Energy Series." From the contents of the declassified papers there emerges, for the first time, a fairly comprehensive picture of the purely scientific work of the atomic-bomb projects since 1940.

A major element of the program of publication of wartime research is the "National Nuclear Energy Series." This is to be a collection of about one hundred and twenty volumes, half of which will be published; the rest will remain secret. At present, only one volume has appeared. It is expected that the sixty publishable volumes will appear over the course of the next few years. Unfortunately, because of the many thorny problems of declassification and the shift in the interests of scientists at the close of the war, the rate of preparation and publication of this series has been much slower than the parallel program of the Radar Project, in which almost all of a planned set of about twenty-five volumes have already appeared.

The lag in the publication of the volumes of the NNES has led to some serious gaps in our present understanding of the wartime advances in nuclear science. To take one example: during the war, the radiochemists studied, in great detail, the characteristics of the many isotopes making up the fission products. These researches were summarized in hundreds of project reports. Practically none of these have yet appeared in print, almost four years after Hiroshima. This delay is not due to security reasons; it is merely the result of a decision to publish all the hundreds of reports simultaneously as volumes of the NNES. Contrast this with the case of nuclear physics. Here scientists decided that, irrespective of the planning of the NNES, it was imperative for rapid resumption

of research to declassify individual papers as quickly as possible. Today research in the academic portions of nuclear physics has reached a fairly normal stage in both AEC and university laboratories.

Parallel with the problem of the publication of wartime research is the treatment of postwar research in nuclear science. With the cessation of hostilities, nuclear scientists surged back to the universities, where research was swiftly resumed. But the increased cost of the tools of nuclear research, coupled with an unprecedented decrease in private endowments, led universities to rely heavily on government support. Hiroshima had taught government that the support of nuclear science was of paramount practical importance; and after the war the armed service branches of government were in the best position, budgetwise, to offer this support. It seemed ironic, at first sight, that the scientists who had been restive under wartime control by the Army Engineers Corps found themselves working at their universities with funds obtained from the Office of Naval Research. In reality, this situation was ironic for an opposite reason. Because of the enlightened attitude of the ONR, the nuclear scientists in the universities worked under a free publication policy, whereas their colleagues, under the civilian Atomic Energy Commission, were still struggling with the publication restrictions inherited from the Manhattan District.

This situation has now been ameliorated by the establishment of "unclassified areas" of research. This is the most important advance in the return to normal publication of nuclear data. Previously, declassification was confined to individual reports; now all reports in an entire field, an unclassified area, can be published without submitting them to the declassification procedure. The effect of specifying unclassified areas of research is that the scientists of the atomic energy projects who work on subjects of purely academic interest now have the same freedom of publication as their colleagues doing identical work in the universities. There remains one important difference: the AEC scientist is not permitted to work on even unclassified research without prior security clearance. Our universities have not placed such restrictions on pure research in nuclear science, even when the financial support derives from the military branches of the government such as the ONR.

To summarize, at present a paper in nuclear science may fall in one of three general classes:

1. Unclassified: Research in these subjects can be conducted in AEC or nongovernmental laboratories, without secrecy restrictions; the reports of these researches can be published in normal fashion.
2. Declassifiable: Work conducted under security restrictions; reports may be published after scrutiny according to the Declassification Guide.
3. Classified: Research specified as restricted by the Atomic Energy Act; therefore, results cannot be published.

As illustration of these three classes, we extract the following partial listing* for each class from the latest report of the AEC to Congress:

Unclassified areas. In general, the unclassified areas cover the pure science related to atomic energy, but not plant processes or specific experimental data of vital project importance. Included are:

1. Pure and applied mathematics, except that applying to specific classified projects.
2. Theoretical physics (except the theory of fission, of reactors, and of neutron diffusion, and weapon physics).
3. All physical (except nuclear) properties of all elements of atomic number less than 90. Nuclear properties of most isotopes.
4. The basic chemistry of all elements (except for the analytical procedures and technology of the production of fissionable materials) and the physical metallurgy of all elements of atomic number less than 83.
5. Instrumentation, including circuits, counters, ionization and cloud chambers, neutron detectors (excluding fission chambers), electronuclear accelerators, such as cyclotrons, betatrons, Van de Graaff generators, etc.
6. Medical and biological research and health studies (excluding work with elements of atomic number 90 and above).
7. Chemistry and technology of fluorine compounds (except the specific applications in AEC installations).

Declassifiable information. The declassifiable information which may be expected to be found in the general literature after official declassification includes:

1. Most reactor and neutron diffusion theory, except for those parts involving semiempirical methods or related to specific assemblies.
2. Certain physical properties of isotopes of elements of atomic number greater than 90, and the nuclear properties (except for certain neutron and fission characteristics) of isotopes of elements greater than 90.
3. Analytical procedures (except for production applications); most physical and process metallurgy of elements of atomic number greater than 90.
4. Medical and biological research and health studies with elements of atomic number 90 and above.
5. Certain properties of experimental reactors, such as: fluxes, neutron distribution not revealing lattices and

* These lists of topics are indicative only. They are not an exact statement of types of data which are unclassified, classified, or declassifiable. The complete lists are themselves classified. All who write, or speak, on atomic energy, and who are uncertain about classification status, should inquire of the Declassification Branch, United States Atomic Energy Commission, Washington, D. C. **They should not try to make their own evaluation on the basis of these partial listings.**

information regarding thermal columns, and the velocity spectrum in the thermal column.

Classified information. The types of information which are clearly classified information include:

1. Information on the production of fissionable material—equipment used, technology, handling, and disposition—including the technology of production of feed materials—and specifically all quantitative and qualitative output data.
2. The technology of production and power reactors, including design, operating characteristics, and working materials.
3. Information dealing with nuclear weapons and their components, including production technology, handling, disposition, testing, and technical data relating to military employment.
4. Certain information relating to the operations and facilities of the United States atomic energy program which may be of value to an enemy in sabotage planning, or in studies of the strategic vulnerability of the United States, or defense potential of the United States with respect to atomic weapons.

It is often overlooked that an important factor in the release of technical information is the widespread demand for popular information on atomic energy. Thus, the AEC must not only decide what technical information may be released to the scientists, but it also must reformulate this information on various levels of complexity, directing it at such specific groups as the personnel of the national military establishments, the industrial executive, the high-school science teacher, the member of national civic organizations like the League of Women Voters, the newspaper reporter and editor, and the "average" citizen. It is as a result of the many pressures exerted by such groups that the definition of restricted data is undergoing constant revision.

In this paper we have been concerned primarily with the restrictions of the technical literature as seen by the scientists. And, in the popular mind, it is the scientist who protests against the hobbling effects of secrecy.

During the past year, the principal pressure for more release of technical information has come not from the scientist but from the military and the industrialist. If the definition of "restricted data" were applied literally, the armed services would be completely stymied in their military employment of atomic energy. Imagine the effect of the cumbersome FBI investigations if they were required for every person participating in such huge operations as those at Bikini or Eniwetok. To cope with this unwieldy situation, the Commission has appointed a Weapons Effects Classification Board. The Board has now devised procedures for the dissemination of information on military use of atomic weapons to armed service personnel without the security provisions which apply to technical personnel of the AEC who actually deal with data concerned with the "development or manufacture of fissionable material and weapons." A notable forward step in the short history of declassification is the current preparation of a weapons-effects handbook, to be distributed for use in training military personnel, and to be made available to the public.

The dissatisfaction of industry with the present publication program of the AEC has been summarized in the recent report submitted to the Commission by its Industrial Advisory Group. The need, in this case, is for different forms of presentation of material as well as the release of more information. The engineers and the industrialists of the country, except those who have participated as contractors or consultants of the Commission, feel that they are being kept in ignorance of information most useful to them. If we are to have an atomic-power industry within this generation, more engineers must be trained in the relevant branches of nuclear science, as well as be apprised of the engineering advances made within the projects. Further, industrialists must have sufficient knowledge of the details of the Commission's operations to permit them to ask those questions which will elicit the data they need in order to decide in what way they may profitably participate in the industrial aspects of the program. In the words of the Advisory Group,

> The essential precondition to increased industrial participation is knowledge of the subject so that industry may recognize opportunities to take part as they arise. Much information has already been published by the Commission, but most of it is not in a form that is useful to industry. In addition, a vast amount of nonsecret information, of potential value to industry, is buried in the files and activities of the Commission. In connection with certain other information, still classed as secret, the continuance of secrecy is of doubtful value. The Commission or groups acting under its auspices should organize and clarify already published material, and issue reports on it in a form useful to industry. In the same way, the Commission should publish in useful form the nonsecret but as yet unpublished information. Still secret information, which is properly declassifiable and of special interest to industry, should be declassified and published.

What are the postwar policies of other countries on the publication of information in atomic energy? This is likely to be one of the knotty questions of the next decade. In some countries like Holland, Italy, and Switzerland, there were no war projects, and there are, at present, no plans for piles or separation plants. In the postwar literature of these countries, papers on nuclear sci-

ence have reappeared; but no discussions of "secret" subjects are published.

England and Canada collaborated with the United States in the secret wartime work on atomic energy. In England, Parliament has enacted laws that are essentially similar to our own Atomic Energy Act in their legal restrictions on the dissemination of information. The Ministry of Supply, the counterpart of our AEC, has amplified and implemented the laws in order to permit research, development, and production within the Ministry, as well as nuclear research in the universities, to be carried on in a tolerable fashion. As far as war research goes, declassification policy is identical in England, Canada, and the United States. In fact, revisions of the Declassification Guide have been made at the joint three-power conferences. It is, however, difficult to predict England's policy with respect to information discovered independently of the joint war effort. As technical information from the operation of the piles at Harwell and at Chalk River accumulates, England and Canada will have to face and solve the same sort of publication problems with which the United States has been grappling. Will England's publication policy remain identical with ours in the future? The answer to this important question will undoubtedly influence our own publication policy.

The case of France is even less clear. She has just announced the completion of a research pile, and the plans for the construction of a second. Some of her scientists working in this field have had no direct access to the classified documents of the British, Canadian, and American war projects, and presumably have unearthed nuclear data independently. Others played an active role in certain branches of the British project, and were intimately associated with the work on the Canadian pile. Furthermore, the head of the French AEC, Joliot, is a prominent member of the French Communist Party. At this writing, in March, the first reports published on the French pile read much like the declassified accounts of the British and U. S. piles.

Perhaps the most interesting, and certainly the most difficult, question is that of Russia's publication policy in atomic energy. The difficulty is partly due to the linguistic barrier that must be hurdled by the average American even to understand the titles of the articles now being published. A further difficulty lies in the fact that most of our libraries lack complete files of Russia's wartime and postwar journals. But the main problem arises from the atmosphere of the cold war, which makes objective study almost impossible.

A summary glance at the titles in the Russian journals reveals a few simple facts. Between the discovery of fission and Russia's entry in the war, articles on such topics as fission products, spontaneous fission, and some general treatments of the chain reaction appeared in their periodicals. Although not nearly so numerous as the articles of the same period in *Physical Review,* the Russian papers exhibit the same enthusiasm for work in fission as that of other countries. During the war, because the issuance of journals was extremely infrequent, as was to be expected from a country so hard-hit, nothing was added to our knowledge of the Russian work in nuclear science.

Since the beginning of 1947, the Russian journals have been issued with a regularity exceeding that of German and French periodicals. How is nuclear science treated in the pages of these journals? In the field of cosmic rays there is a spate of articles. Occasionally, papers appear on subjects like artificial radioactivity, nuclear reactions, and theoretical nuclear physics. But topics like the fission process, the chain reaction, the theory and construction of piles, the separation of isotopes, are conspicuous by their absence. When one couples this with the fact that some of the members of the German atomic war projects, with certain knowledge of these subjects, are now in Russia, it is reasonable to assume that publications are being withheld. The pattern in Russia is much like that in Germany and in the United States a decade ago, as described earlier in this article. But the suppression of publications in Russia and the very cautious release of information of a purely academic nature in the United States are merely two different aspects of the same fundamental fact —the existence of an atomic arms race.

In this country we are beginning to enjoy a considerable measure of our prewar publication freedoms. And it is reasonable to expect further expansion of the known areas in nuclear science in response to peacetime demands of scientists, engineers, industrialists, legislators, and lay citizens here and abroad. It is clear, however, that the literature of atomic energy in the coming decade will be critically influenced by the temperature fluctuations of the "cold" war and by the intellectual level of our foreign policy.

RADIO ASTRONOMY

CHARLES R. BURROWS

Dr. Burrows (Ph.D., Columbia, 1938) is director of the School of Electrical Engineering at Cornell University, where extensive research is being done in the new science of radio astronomy. He has been a member of the National Television Systems Committee and of several radio engineering committees working on problems of wave propagation, transmission lines and antennas, and multiplex transmitters.

RADIO astronomy, like the older branches of astronomy, is concerned with the measurement of extraterrestrial electromagnetic radiations, but the frequency range and experimental techniques are different. Radio astronomy gets its name from the fact that the measurements are made at the same frequency range as that used for radio communication. The experimental techniques are the same as those of the radio engineer, so it is natural that experimenters in this new branch of astronomy should be radio scientists.

Early astronomical observations were made with the naked eye. The sensitivity and positional accuracy of the observing apparatus were greatly extended with the invention of the optical telescope by Galileo. The frequency range of the electromagnetic radiations observed was extended slightly on either side of the visible by the use of photographic processes involving emulsions sensitive to either the utraviolet or the infrared. The use of thermocouples and photoelectric cells with the same type of telescope makes possible measurements further in the infrared. By using all these methods it is possible to make measurements over a ten to one frequency range (a decade) that includes the visible frequencies.

Observations in radio astronomy extend over a frequency range of approximately 3.5 decades from 10^7 to 3×10^{10} cycles per second (a wavelength range from 30 meters to 1 centimeter). The experimental techniques are applicable at frequencies both lower and higher than these, but absorption by the earth's atmosphere effectively isolates us from electromagnetic radiations outside this window. At lower frequencies the ionosphere (ionized region of the upper atmosphere) effectively shields the earth from the outside, and at higher frequencies absorption by molecules of oxygen, water vapor, carbon dioxide, and methane is substantially complete. This molecular absorption extends for a range of about three decades, beyond which measurements can again be made by thermocouples.

Equipment for observations in radio astronomy looks more like a radio receiver or a radar set than a telescope, although the receiving antenna for measurements on the higher frequency may be put on the same type of equatorial mounting as that used for the larger optical telescopes, as shown in Figure 1.

The antenna and electronic equipment associated with a radio telescope are similar to those used with a radio receiver, but the frequency spectrum and direction of arrival of the signal are different. The signal received on a radio telescope extends over a wide frequency range—in fact, it has many of the properties of thermal noise and sounds like thermal or set noise if the electromagnetic vibrations are converted to sound by a loud speaker. For this reason the signals are called solar noise or galactic noise, depending upon whether their origin is in the sun or elsewhere in our galaxy. Because the received power is spread over the entire frequency spectrum instead of being concentrated near the carrier frequency of a communication signal, it is measured in watts per cycle rather than watts, and many of the devices, such as electrical filters which aid in improving the sensitivity of communication receivers, do not perform the same function for a radio telescope.

The nature of the signal received by a radio telescope also places much more importance on the directivity of the receiving antenna than is usual in a communication system. Galactic noise is more intense near the center of our galaxy in the constellation of Sagittarius, but it comes from all directions, so that the signal is measured in watts per cycle per second per steradian. This requires an accurate knowledge of the directional characteristics of the receiving antenna used for the radio telescope. Because of the extremely large aperture needed to obtain even moderate directivity, it is necessary to solve an integral equation to determine the signal received from any particular direction.

The power received by a radio telescope may be expressed as:

$$P = \int I(x,y,z,\theta,\phi,\nu,\rho,t)\, G(\theta,\phi,\nu,\rho)\, F(\nu) \sin\theta d\theta d\phi d\nu$$

where I is the specific intensity of the incident electromagnetic radiation. It is a function of the

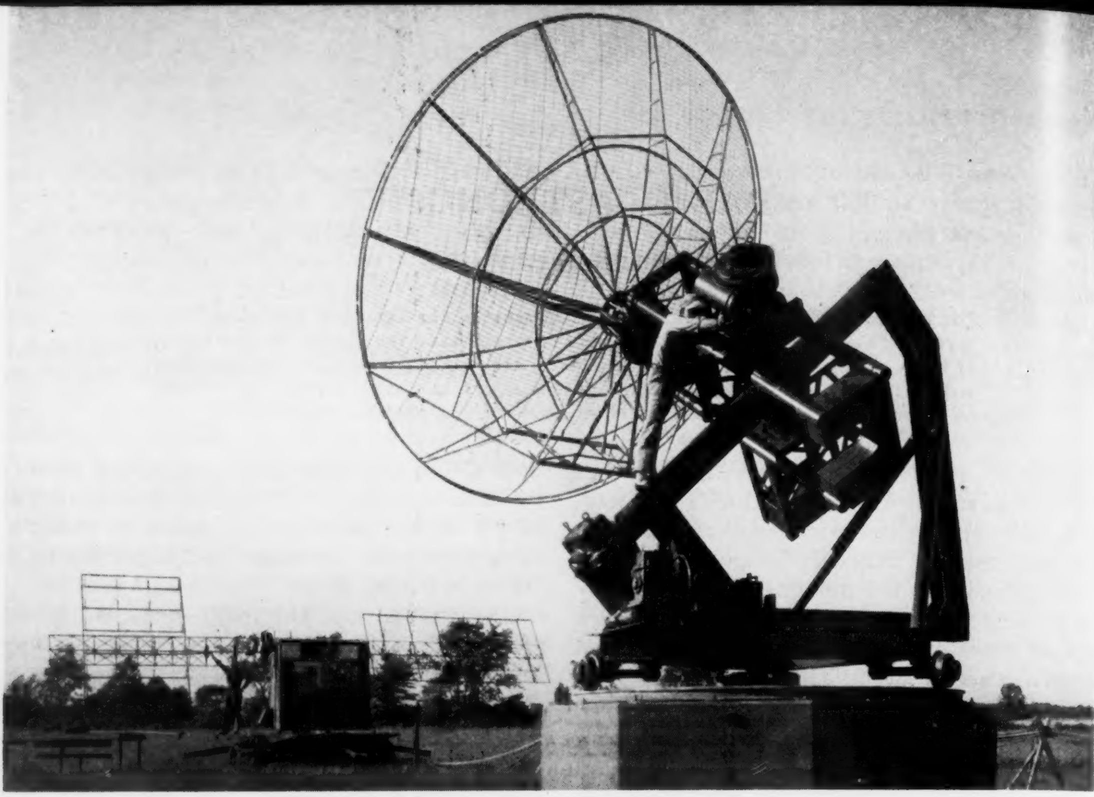

FIG. 1. Radio telescope nearing completion at Cornell University. The 17-foot saucer-shaped radio antenna will collect radio waves from 5 to 60 inches in length.

position or location of the radio telescope (x,y,z), the direction of the source of the radiation (θ,ϕ), its frequency (ν), polarization (p), and usually the time (t). The contribution of the radiation to the output of the telescope depends upon the directional characteristics of the antenna $G(\theta,\phi,\nu,p)$. This is not only a function of the direction (θ,ϕ) but of the frequency (ν) and polarization (p). The dependency on frequency is usually avoided by making the frequency response of the telescope such as to limit the response to a band of frequencies sufficiently narrow that the antenna gain and directivity are substantially the same over the entire band. The response is proportioned to the solid angle ($\sin \theta d\theta d\phi$) and the frequency interval $(d\nu)$. The telescope measures the value of this integral, whereas the desired quantity is the specific intensity, I, which occurs under the integral sign. By designing the telescope so that all the variables are independent of frequency throughout the band-width for which there is a measurable response, the integration of $F d\nu$ may be made separately, giving the band-width of the telescope, B. This leaves the following integral to be solved:

$$P = B\int I(\theta,\phi)G(\theta,\phi)\ \sin\theta d\theta d\phi.$$

Because of the fact that electromagnetic radiation is polarized and radio antennas show a preference for a particular polarization, this equation must be solved twice. If the response is found to be a function of time, further complications result.

If the source of radiation subtends an angle that is so small that the response of the antenna is substantially constant over this angle, then the integration with respect to angle may be performed to give

$$P = I\pi R^2/r^2,$$

when R is the radius of the source, r is the distance to the source, and $\pi R^2/r^2$ is the solid angle subtended by the source. For many radio telescopes the sun subtends such a small angle, so that data on solar noise are more readily reduced to specific intensity than data on galactic noise, provided the measurements are made under conditions for which the background galactic noise does not contribute appreciably. Accordingly, solar noise will be considered first.

The spectrum of electromagnetic radiations from the sun as received at the earth's surface is given in Figure 2. The fine curve gives the radiation that would be received at the earth if the sun were a black body at 5,713 degrees absolute and there were no absorption in the earth's atmosphere. The integral of this curve gives the correct total radiation received at the earth. This equation

$$I = \frac{2h\nu^3}{c^2(e^{h\nu/kT}-1)} \longrightarrow \frac{2k}{c^2}\ T\nu^2$$

gives a relationship between specific intensity, I, and apparent temperature, T. Here h is Planck's constant, k is Boltzman's constant, and c is the velocity of light. The expression at the right, which applies at radio frequencies, gives a particularly

simple relationship between specific intensity and apparent temperature. Since the unit of specific intensity is somewhat difficult to visualize, the term "apparent temperature" is widely used. It does not imply that the source is in temperature equilibrium, but merely that the specific intensity in the frequency interval under consideration is the same that would be produced by a black body at this temperature.

In the visual frequency range the sun radiates as a black body at a temperature of about 6,000 degrees. At higher frequencies in the ultraviolet, the solar radiation is somewhat reduced because of absorption in the solar atmosphere. At frequencies above 1.5×10^{15} cycles per second, the ozone layer in the earth's atmosphere acts as an effective shield. At the infrared side of the visible range, the sun radiates as a black body at about 7,000 degrees, but the radiation received at the earth's surface is greatly reduced by the absorption bands of carbon dioxide, water vapor, and methane. At frequencies below about 10^{13} cycles per second, atmospheric absorption is substantially complete. At still lower frequencies, microwave radio techniques allow the observation of the sun through the absorption caused by atmospheric gases. Radio astronomy makes measurements through the window extending from 3×10^{10} to 10^7 cycles per second, at which frequency the conductivity of the ionosphere of the earth again acts as an effective shield.

At the high-frequency edge of this radio frequency window in the earth's atmosphere, the apparent temperature of the sun is only slightly greater than that in the visible frequency range. At the lower frequencies, however, the apparent temperature of the sun increases, until at frequencies below about 3×10^8 cycles per second, the apparent temperature of the sun is of the order of one million degrees absolute. This increase in the apparent temperature of the sun is a natural result of the solar ionosphere. The mean kinetic temperature of the electrons in the solar corona which make up the solar ionosphere is believed to be about a million degrees, from spectroscopic measurements. The solar ionosphere is opaque to the lower radio frequencies, so that the solar noise at these frequencies originates in the solar corona rather than in the photosphere. Accordingly, the apparent temperature of the sun at the lower frequencies is that of the solar corona rather than that of the photosphere.

In addition to this radiation from the quiet sun, bursts of solar noise upwards of a thousand times this value have been observed at the lower radio frequencies. Figure 3 shows some samples of the records of solar noise at a frequency of 205 megacycles per second obtained at the Cornell Radio Observatory. The upper chart shows the noise from a quiet sun. This is the minimum value of solar noise measured at this frequency. In the period represented by the center diagram there were several bursts of solar noise to values three to six times the quiet sun. During the period represented in the lower record the general level of the

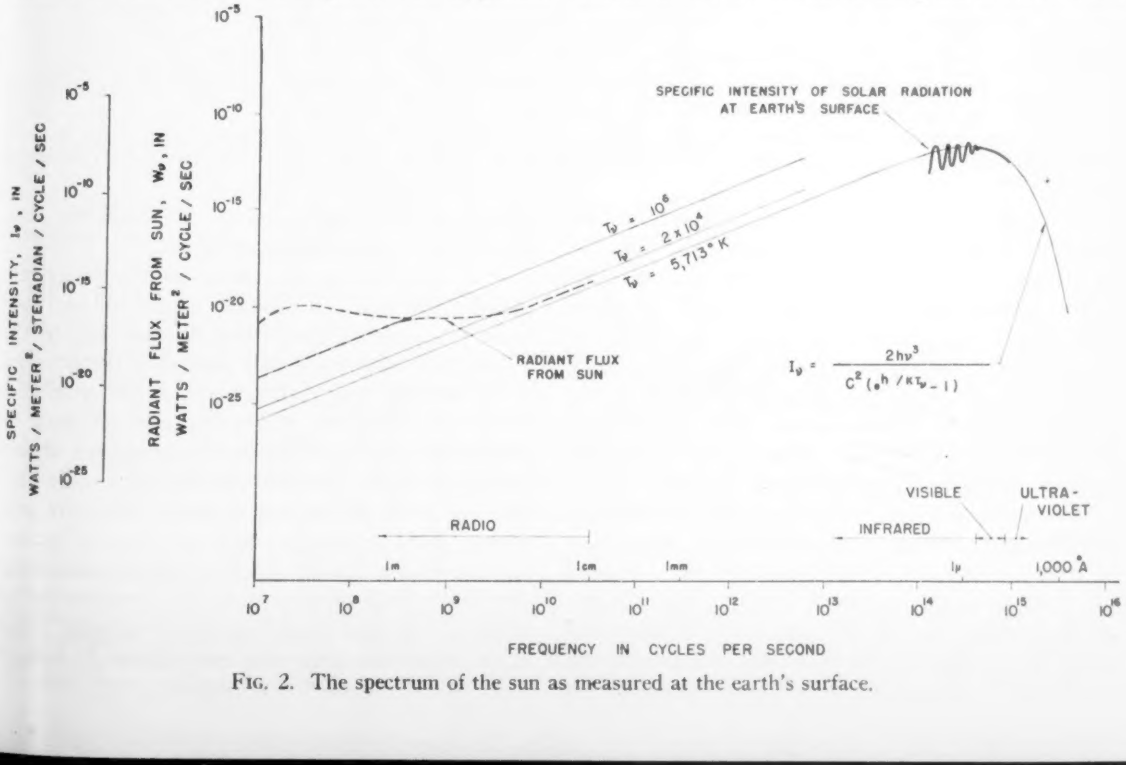

FIG. 2. The spectrum of the sun as measured at the earth's surface.

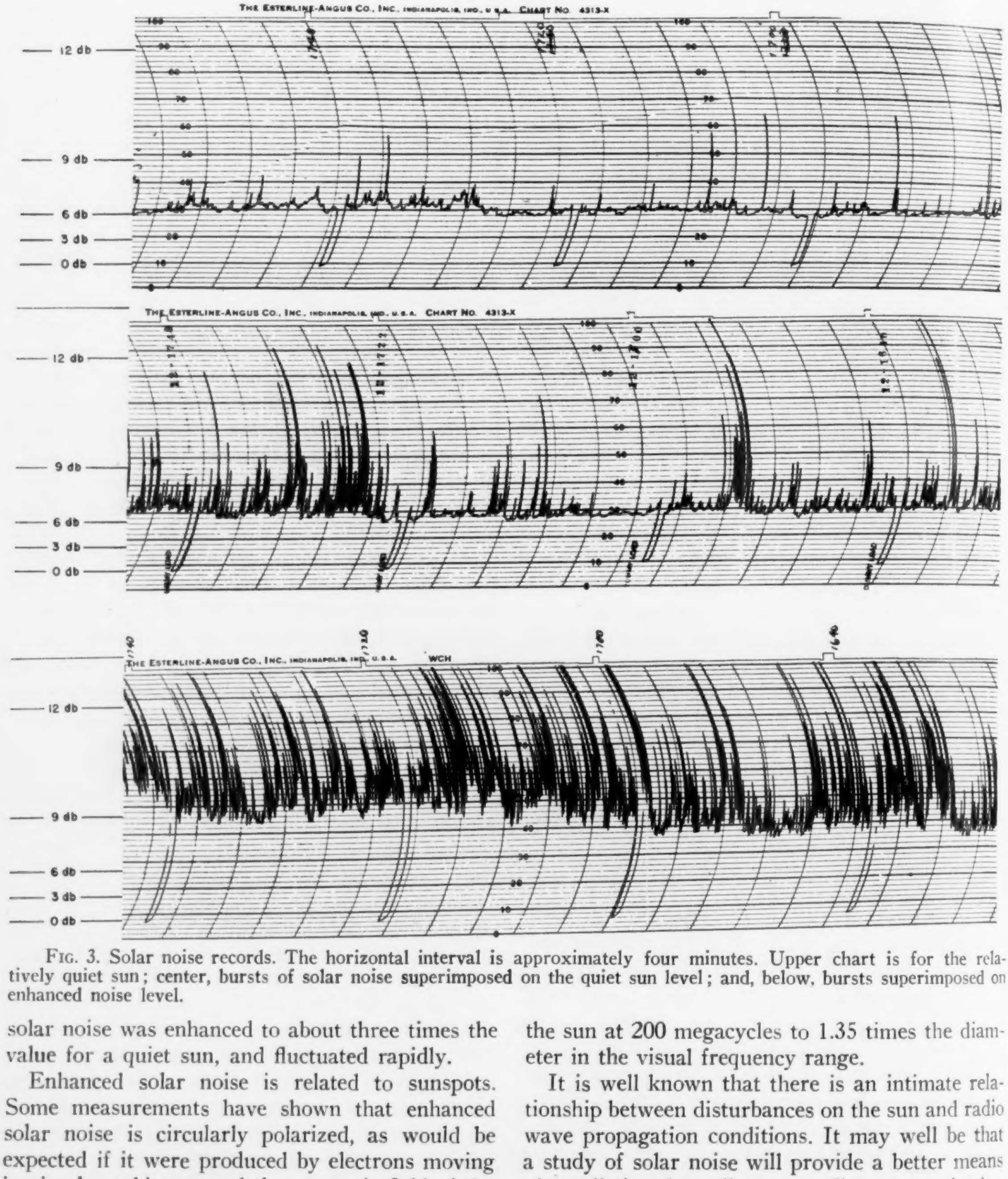

FIG. 3. Solar noise records. The horizontal interval is approximately four minutes. Upper chart is for the relatively quiet sun; center, bursts of solar noise superimposed on the quiet sun level; and, below, bursts superimposed on enhanced noise level.

solar noise was enhanced to about three times the value for a quiet sun, and fluctuated rapidly.

Enhanced solar noise is related to sunspots. Some measurements have shown that enhanced solar noise is circularly polarized, as would be expected if it were produced by electrons moving in circular orbits around the magnetic field of the sunspots. Other measurements have shown the source of enhanced solar noise to be in the immediate vicinity of large sunspot groups.

Measurements made during a solar eclipse suggest that the source of enhanced solar noise is to be found in the prominences and flocculi. The area of uneclipsed prominences and flocculi showed good correlation with the intensity of enhanced solar noise. During the time of this eclipse the prominences increased the effective diameter of the sun at 200 megacycles to 1.35 times the diameter in the visual frequency range.

It is well known that there is an intimate relationship between disturbances on the sun and radio wave propagation conditions. It may well be that a study of solar noise will provide a better means of predicting long-distance radio communication conditions. Besides giving us another tool for observing solar activity, the measurement of solar noise is actually the measurement of a radio wave that has been propagated through the entire ionosphere. This provides us with a means for measuring the ionosphere above the height of maximum density, which of course is not possible by the usual ionospheric sounding measurements. Hence solar noise measurements may allow us to learn more about the earth's atmosphere.

Measurements of galactic noise may result in a greater contribution to astronomy than measurements of solar noise. The stars of our galaxy, of which the sun is one, are concentrated near the plane of the Milky Way, with a denser spherical concentration at the center of the galaxy in the direction of the constellation Sagittarius. Besides the stars, there are interstellar molecules and dust particles which in the aggregate absorb so much energy at visual frequencies that there is some question whether it is possible to observe the center of the galaxy with optical telescopes.

Measurements of galactic noise on three frequencies are shown in Figure 4. The abscissa gives the galactic longitude, or the angle around the plane of the Milky Way. The ordinant gives the galactic latitude of the angle from this plane. The specific intensity is shown by contours. The numbers on the contours indicate the number of decibels the specific intensity is above 10^{-21} watts per square meter per steradian per cycle per second. (An increase of 3 decibels in the specific intensity is equivalent to double the specific intensity. An increase of 10 decibels in specific intensity is equivalent to increasing the specific intensity tenfold.) At each of the three frequencies the major maximum is in the constellation Sagittarius at a galactic longitude of about 330°. The specific intensity in this maximum direction is roughly the same order of magnitude at each of the three frequencies. There is a secondary maximum in the constellation Cygnus. For the two higher frequencies, the curves represent the measured received power rather than the specific intensity, since sufficient data were not available to solve the integral equation. At the lowest frequency, however, the contours represent a solution of a differential equation giving the specific intensity. The contours on all three frequencies show the general distribution of intensity that is found at visual frequencies.

Perhaps the most startling result from the discovery of galactic noise is the observation of intense apparent point sources. These are shown in Figure 5. The point sources were found by interferometer measurements, either by using two antennas pointing at a high angle of elevation or by using an antenna at its image in the sea. By this means it has not only been possible to determine the position with good accuracy but also to determine an upper limit to the size of the source. The source in

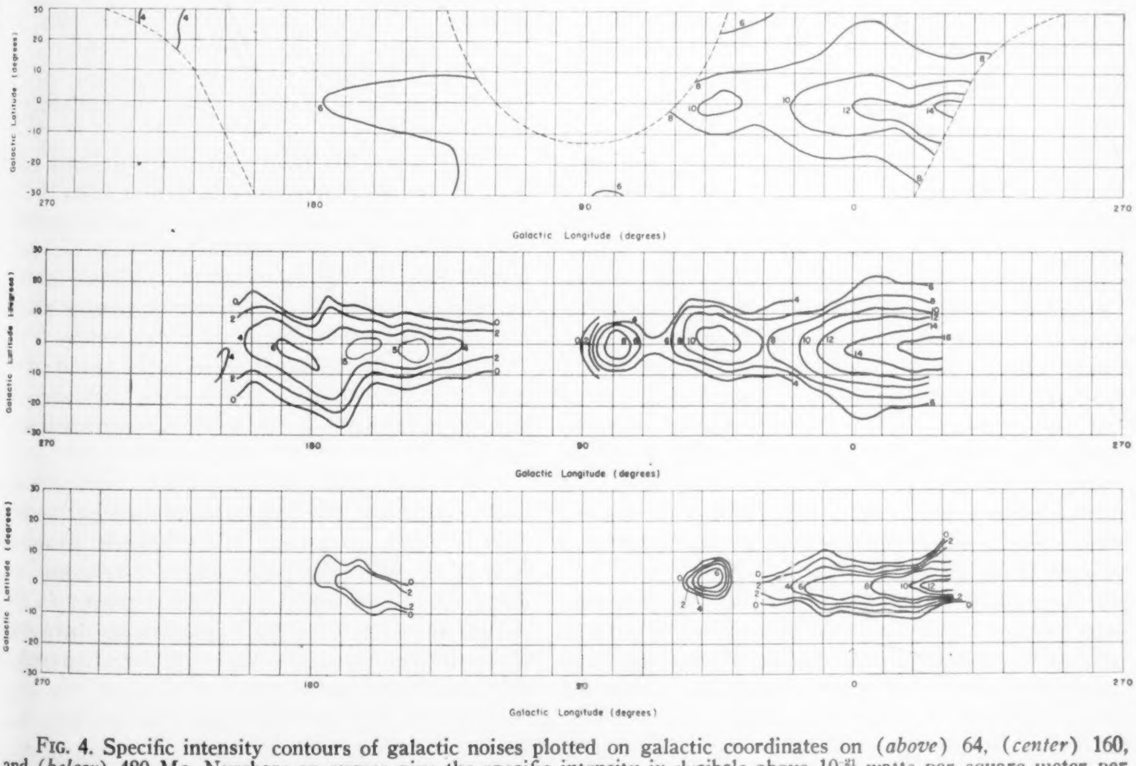

FIG. 4. Specific intensity contours of galactic noises plotted on galactic coordinates on (*above*) 64, (*center*) 160, and (*below*) 480 Mc. Numbers on curves give the specific intensity in decibels above 10^{-21} watts per square meter per steradian per cycle per second. Upper graph represents the solution of the integral Equation 2 by Hey, Phillips, and Parsons, using data obtained by them on a frequency of 64 Mc. The second and third graphs represent the received power obtained, measured by Reber with his equipment on 160 and 480 Mc, respectively. In constructing these two diagrams, advantage was taken of a careful analysis of Reber data made by Miss Ruth Northcott, of the David Dunlap Observatory, to determine the galactic pole, which was kindly made available to the writer.

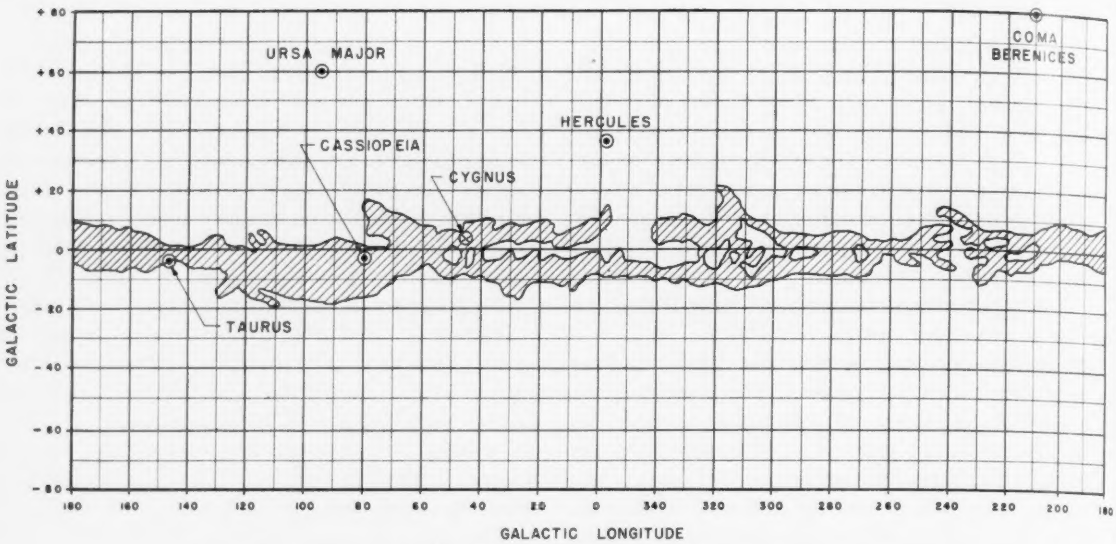

FIG. 5. Point sources of galactic noise: ⊙, constant source; ⊕, variable source.

Cygnus is smaller than the limit of measurement, which is approximately eight minutes of arc in diameter. The most startling thing about these point sources is the fact that it has been impossible to observe anything that might be identified with them at either the visual or infrared frequencies. Apparently, the radio astronomers have observed something that cannot be seen with the ordinary telescope. Although some of these point sources appear to be constant, others have been observed to show marked variations with time. An unexplained fact about these point sources is the intensity of the galactic noise received from them. Even if the entire solid angle which represents the maximum possible size of the source were completely filled with stars radiating energy of the same intensity as our sun under enhanced solar noise conditions, the total energy radiated would fall short of that observed by a factor of the order of one thousand. Also, the radiation from these point sources has a random polarization rather than the circular polarization found for enhanced solar noise. Clearly, these point sources represent some astronomical phenomena that have not heretofore been observed.

None of the hypotheses that have been proposed can explain all the observed phenomena of galactic noise. Undoubtedly some of the phenomena have one origin, and other phenomena have another. At present it is not possible to say whether the origin of galactic noise is to be sought in the stars or in the interstellar gas or dust particles. One hypothesis is that galactic radiation is caused when an electron approaches a hydrogen nucleus in a parabolic orbit. This is the process that is often referred to as the free-free transition of electrons in the field of a proton. Another suggestion is that the electrons in interstellar space are radiating as classical oscillators.

It is also possible that some of the galactic noise is the result of scattering of radiation from B-type stars by the electrons in interstellar space. A measurement of the polarization of galactic noise should help in determining the validity of this hypothesis, since the scattered radiation should have a preferred direction of polarization.

It may be that galactic noise is the result of the sum of radiation from many stars that are producing radiations of the type of enhanced solar noise.

There are many questions about both our sun and our galaxy that can be answered by the new field of radio astronomy. This branch of science is now at about the point where astronomy was when Galileo invented the optical telescope. Scientists in this new field are just asking themselves the pertinent questions that will be answered in the years to come.

POETIC SCIENTIST

CHARLES J. ENGARD

Dr. Engard (Ph.D., Chicago, 1938) has been on the faculty of the University of Hawaii for the past ten years and associate plant physiologist at the University Agricultural Experiment Station since 1947. He has published a study on Organogenesis in Rubus. *His present research is in the morphogenesis and growth hormones in sugar cane.*

Minds like Goethe's are the common property of all nations; and, for many reasons, all should have correct impressions of them.—Thomas Carlyle.

"FOR more than half a century I have been known as a poet in my fatherland, and undoubtedly also abroad; or at any rate I have been permitted to pass for one. But the fact that I have busily occupied myself with Nature in all her general physical and organic phenomena and have constantly and passionately pursued seriously formulated studies—this is not so generally known; still less has it been accorded any attention."

Thus wrote Johann Wolfgang von Goethe a few years before his death in 1832. The greatness of the poet had blinded people to the greatness of the man of science.

The whole educated world is acquainted with *Faust, Werther,* and *Wilhelm Meister*; but little is known about an almost equally important phase of Goethe's life. This was his scientific life, stemming from, and maintained until his death by, a profound interest in nature. He performed a great variety of experiments, and recorded many observations on plants, animals, minerals, rock formations, light, and colors. Many of his observations were remarkably correct, and some of the conclusions he drew have had a marked influence in science, persisting down to the present time. The most important aspect of his scientific studies, however, was his method of approach and of analysis of biological phenomena. The method was one of comparison for similarities between things rather than of contrast for differences, and because of it Goethe was able to establish the science of comparative anatomy and to achieve the basic concept of organic evolution.

Two tendencies may be recognized in the thinking of men. One of these is the analytic, or separatist, kind of thinking, whereby fine differences between things are emphasized; the other is the synthetic, where fundamental similarities of things are ordinate, and the differences are subordinate. Goethe was a thinker of the latter kind, a fact that is superbly manifest in his creative writings. He was, furthermore, a lover of nature, and he had an unlimited curiosity concerning many aspects of natural phenomena. When his profound interest in nature led him to study problems in biology, his method of thinking soon set him apart from his contemporaries. For Goethe was not just a recorder and separator of facts, but was, in addition, a correlator and comparator of them. From his first experiments he began to see, or rather to sense, a unity of form among organisms, however variable the specific structures might be. He had the inherent feeling that in nature all objects are patterned after a form; that, for instance, a unity of structure or basic sameness prevails among plants and among animals. This idea was dominant in all his studies, and he sought confirmation of it in the accumulation and comparison of facts and observations. And thus he came close to formulating the theory of descent—the principle of organic evolution.

Goethe's first interest in biology was in osteology. He became a student of the anatomist Lavater, and progressed so quickly in his studies that he was able to aid informally in the work which led to the publishing, in 1776, of Lavater's *Physiognomische Fragmente.* His interest in botany was kindled when he moved to Weimar in 1775, where he accepted a political post under Karl August, the Duke of Saxe-Weimar. He became fond of the surrounding forests and meadows, and especially of the Duke's beautiful gardens. He was permitted to take up residence in the quiet and secluded *Gartenhaus* in the ducal gardens, and here he did much of his writing and embarked upon a lifetime study of nature.

He applied his comparative method of analysis first to the problem of the intermaxillary bone in man. This bone—the small center bone of the upper jaw, containing the incisor teeth—is separate and distinct from the other jawbones in animals exclusive of man. In man, the bone is fused left and right with the upper jawbone, and in most normally developed skulls there is no line of demarkation of one from the other. Anatomists of the day, finding no evidence of the intermaxillary bone, maintained that it did not exist in man, and one of them even considered the absence of this bone to be the one important mark distinguishing man from the apes. To Goethe, with his preconceived archetype of animal—the essence of his philosophy of

the unity of nature—such a distinction between man and the other animals could not exist. In the animals the intermaxillary bone held the incisors; man had incisors; therefore, according to his doctrine, man must have an intermaxillary. Goethe discovered the bone in the latter part of March 1784. Upon comparing the skulls of animals he noted that the bone varied with the nutrition of the animal and the size of its teeth. Also, in some animals the intermaxillary bone is not always separate from the jaw as it usually is. He discovered that the sutures were clearly evident in the skulls of children as compared with those of adults. Despite the importance of these researches, however, forty years passed before his discovery was fully recognized by anatomists; nevertheless, Goethe's method of comparing the structure of various animals in various stages of development was the beginning of the science of comparative anatomy.

Goethe's interest in the animal skull was rekindled during his visit in Italy in 1786–87, an interest that resulted in the development of a concept which has remained influential in the thinking of anatomists down to the present day. While he was wandering in a cemetery near Venice, Goethe came upon the skull of a ram which had been cut longitudinally. It occurred to him upon inspection that the face of the ram was composed of three vertebrae, and later he wrote: "The transition from the anterior sphenoid to the ethmoid was evident at once." Thus was born the vertebral theory of the skull.* This famous theory holds that the skull is composed of three or more vertebrae variously modified, but conforming to the same plan as those of the trunk. The theory was criticized by Huxley in 1858, and by others since then, and was gradually replaced by the current "segmental theory." This holds that the head is segmented like the trunk of the animal, the distinction between head and trunk being less marked in more primitive animals. The head region of the animal is now considered to be the result of the frontal segmentation of the body being modified and fused. The posterior portion of the skull is homologous with the segments of the spinal column. The vertebral theory, although greatly modified, has not been entirely discarded, a manifestation again of the debt modern science owes to the versatile mind of Goethe.

Goethe began his botanical studies at Weimar, attracted first to mosses, fungi, and algae. But later he became particularly interested in the cycle of development of the flowering plants, beginning with the germination of the seed and ending with the formation of the flowers. He began to read the works of the great contemporary biologist Linnaeus, and through this contact another source of stimulation was found. Busy as he was with his scientific and literary work at Weimar, his thoughts on the various subjects of nature did not begin to crystallize until he undertook his journey to Italy. His sojourn in that country was one of the most important episodes in his life, for there, enhanced by the climate and vegetative luxuriance of the land, his ideas of nature, especially in respect to plants, began to form.

All during his visit Goethe kept a diary in which he made notes of his observations of plants and recorded the variations in the structure of plants with variations in environment. He observed and made notes on germination, growth, and the formation of flower and fruit. He began to evolve the concept of plant metamorphosis, and returned to Weimar convinced he had found the secret.

In 1790, at the age of forty-one, Goethe published the results of his studies on plant development, the most famous and lasting of his scientific writings. The substance of this essay, entitled *Versuch die Metamorphose der Pflanzen zu erklären,* or *An Attempt to Explain the Metamorphosis of Plants,* which he later published under the title *Die Metamorphose der Pflanzen,* is now known as the Doctrine of Metamorphosis. During his Italian journey Goethe had written: "All is leaf, and through this simplicity the greatest diversity becomes possible." This means that the basic structure of the plant is the leaf—not necessarily the leaf one sees on any particular plant, but a leaf as an idea, or plan, from which all other parts are made, just as, for instance, the potter may have in mind not a real but an imaginary form of vessel, from which idea he makes a great variety of vases, pots, and urns.† Fundamentally, these receptacles are modifications or transformations of one type. (No matter what you choose to call them, all pots are basically alike.) From this archetype, or imaginary model, a great diversity of forms can be related. Goethe, who, a few years earlier, in trying to find similarity in the form of skulls discovered the intermaxillary bone, now evolved the doctrine

* Goethe did not publish has views on the theory but referred to it in letters and discussed it privately with friends. In 1806, the anatomist Oken, unaware of Goethe's ideas, independently arrived at the same conculsions, but he more thoroughly investigated the problem and published in the following year a dissertation on the subject. To Oken, therefore, is usually given credit for the theory, based on priority of publication, although occasionally Oken and Goethe are cited as co-originators of the theory.

† Goethe used the German word *Blatt,* which applies to the foliage leaf; but Goethe's *Blatt* is not just a leaf as commonly understood, but a leaf as a type or idea, and should perhaps have been designated by the word *Urblatt,* or leaf prototype.

of metamorphosis. This doctrine holds that all appendages of the plant—seed leaves, foliage leaves, sepals, petals, stamens, and the parts of the fruit—are variations of a fundamental form or model, the leaf. Furthermore, progressive change occurs in the form of these structures, as the plant develops from embryo to adult, beginning with the fleshy "unleaflike" seed leaves, or cotyledons, as the botanist calls them (the "halves" of the peanut or bean seed), and ending with seed pods.

Intermediate between these two extreme types of leaves are the foliage leaves (ordinarily understood as "leaves"); bracts, such as the leafy structures enclosing a bud; sepals, the reduced leaflike green objects at the base of the flower; the petals, often large, highly colored, usually obvious parts of the flower; and the stamens, bearing the pollen sacs at their tips. At the end of the series of modifications are the most highly transformed of the fundamental leaf. These comprise the fruit, and they may be fleshy or dry, simple or fused into groups. A good example of this kind of modified leaf is the pod of the pea plant. When the pod is split open longitudinally, and flattened out, there is before us, according to Goethe's concept, a leaf bearing the structures of reproduction—seeds—along the edges. The mature pod is, therefore, a leaf with its two edges folded together. After the stamens, the pistils are the "perfectest" type of leaf, whose pollination terminates one generation of plant growth and initiates the next. Goethe says:

> Whether the plant sprout, blossom, or bear fruit, it is always the same organs which, in various functions and with frequent changes in form, fulfill the dictates of Nature. The same organ which on the stem expanded as a leaf and assumed a highly diverse form, will contract in the calyx, expand again in the petals, contract in the sex organs, to expand again in the fruit.

This, in brief, is the doctrine of metamorphosis, now referred to by modern plant anatomists as the concept of homology. Every person who has studied elementary botany is acquainted with the theory to a greater or lesser degree.

One of the most important aspects of Goethe's comparative method of thinking might, if he had pursued it further, have made him one of the world's greatest biologists. This was his close approach to the theory of organic evolution.

The seeds of this theory, which did not attain complete formulation until the publication of Darwin's *Origin of Species* in 1859, were beginning to germinate in the mind of Goethe even earlier than they did in the minds of the more generally recognized forerunners of Darwin. For instance, Lamarck, noted for his theory of the inheritance of acquired characters, did not conceive the idea until 1794, and did not formulate it articulately until 1809, whereas Goethe had given some expression to the thoughts as early as 1790 in his essay on plant metamorphosis, and had given a clear exposition of it in an essay on the subject, *Versuch einer allgemeinen Vergleichungslehre*, or *An Attempt to Formulate a General Comparative Theory*, in the early 1790s.

It was inherent in Goethe's approach to all living things that he compared them to seek more for similarities than for differences. This mode of thinking first became evident to him when he was studying the work of Linnaeus. From Linnaeus he learned much, but Linnaeus' approach to the plant kingdom did not satisfy Goethe. There was a fundamental difference between their concepts of the organization of the plant kingdom, for where Linnaeus was disposed to separate, distinguish, and classify the myriad plant forms as different and distinct species, Goethe sought always the basic similarity among those forms, and to fit plants and animals into an anatomical type. (Goethe had said: "Separating and counting was not in my nature.") The type, to be sure, was a hypothetical one, an idea, but one which enabled Goethe, and most botanists since, to understand parts that are different in appearance, but alike in plan, or related to the same ancestral form. From the versatility of this type Goethe says there are derived without exception the many genera and species known to us. The type still exists through all the transformations of form in plants and animals. In his *History of My Botanical Studies*, Goethe wrote:

> Through direct observation my attention was powerfully directed toward the circumstance that each plant seeks its opportunity and demands a condition in which it may appear in fullness and freedom. Mountaintop, deep valley, light, shade, aridity, moisture, heat, warmth, cold, frost, or whatever the condition may be, species and genera are necessary if plants are to grow with full strength and abundance. To be sure, in certain places and in many situations, they yield to Nature and allow themselves to be swept into variations, without giving up completely, however, the form and quality which they had acquired through their own efforts.

There can be little doubt that Goethe was a forerunner of Darwin. The discourse on the influence of environment on speciation refers to natural selection, and "form and quality—acquired through their own efforts" can be construed as hereditary (genetic) sequence. His thinking is phylogenetic, and his proximity to the modern theory of descent is evident in his writings. Goethe seems to have recognized the impossibility of distinguishing between the primitive plants and animals. Perhaps this was a result of his observations of microscopical plant and animal forms. He had stated:

> When one considers plants and animals in their most

> rudimentary stage they are hardly to be distinguished . . . creatures gradually evolving as plants and animals out of a relation in which it is scarcely possible to draw a separating line between them, develop toward perfection in two opposite directions, so that in the end the plant culminates in a tree, enduring and stationary, while the animal reaches its highest degree of locomotion and freedom in its crowning representative, man.

Surely this is the modern theory of descent, simply stated. On another occasion Goethe said: "Who knows but that, after all, the complete man only indicates an aim at a still higher mark?" (In an essay on some fossil bones of an ox, Goethe referred to the "ancient creature" as the parent stock from which the common ox and zebra may be descendants.)

Finally, in his conversations and correspondence, Goethe often referred to the *Principle of Continuity*. Nature would not make a horse "if all animals did not precede mounting as by a ladder, to the structure of a horse." And in August 1796—two years after he wrote *Wilhelm Meister*—he wrote: "I am more than ever convinced that one can arrive at an excellent understanding of organic nature by means of the concept of continuity." It was impossible for Goethe to view living things in any other light than as a continuity of transformation, resulting in the production of a variety of structures based on a fundamental plan. In Goethe's writings one can find the same reasons for variations and transformations as set forth in the modern theory of evolution: adaptation, disuse of some organs and emphasis on the use of others, inheritance, "survival of the fittest," and so on.

But let us point up the concept with one more quotation: "Form is something mobile, something becoming, something passing. For the doctrine of formation is the doctrine of transformation. Metamorphosis is the key to the whole alphabet of nature." Darwin, a generation later, did not have an entirely new idea.

Another facet of the versatile mind of the German poet reflects his dual interest in the laws of nature and in art. What would be more natural than for Goethe to inquire into one of the crowning achievements of nature's "crowning representative"—the development of art? Goethe, by nature an artist, had made many accurate sketches and paintings of plants, rock formations, scenes, and had designed stage scenery. An enthusiast for Greek literature and art, he acquired a sizable collection of casts of Greek sculpture, and made excellent sketches of some of them. He was from youth always deeply concerned with painting, paints, colors, lights and shadows, and the effects these things produced upon people. He held many discussions with painter friends on the subject of colors, their mixtures, and their aesthetic effects, but his friends' ideas were vague and unsatisfactory to Goethe. He began to theorize on the nature of color and lights and shadows. He spent more time on this study than on any of his other scientific subjects, and wrote several essays on it. He performed a large number of experiments with prisms and simple optical equipment, and his observations were precise and thorough, although many of his conclusions were erroneous. He first advanced his ideas on light and color tentatively to the public in 1791 when he published his *Beiträge zur Optik,* or *Contribution to Optics*. When the theory was ignored by the physicists, Goethe merely was stimulated to greater efforts on behalf of it; in fact, he became very sensitive to criticism of the theory, and it became his greatest love. He once remarked: "As for what I have done as a poet I take no pride in whatever . . . but in my century I am the only person who knows the truth in the difficult science of colors,—of that I say I am not a little proud." Eighteen years after publication of his *Contribution to Optics* he produced the *Farbenlehre,* or *Theory of Colors*. The theory, so well documented in the publication, can be given only a brief, and therefore somewhat unfair, accounting here.

Because he was pressed to return some optical apparatus he had borrowed and kept for a long period, Goethe picked up a prism and looked through it at the white wall of his room. Instead of the Newtonian spectrum he had expected, he was astonished to see the colors only where the

white wall was interrupted by opaque objects from which no light was being reflected. When he directed his sight toward the window, the frames showed some color, but not the sky. He immediately exclaimed: "Newton's theory is false!" This hasty conclusion, based on ignorance of Newton's principles and sound experiments, resulted in almost a lifetime devoted to overthrowing Newton's theory, when, in fact, he was fighting his own error. His first experiment was to view through a prism a white disk on a black background; it gave him the spectrum at the boundaries, as in Newton's theory. A black disk viewed against a white background gave a similar result. He concluded that color is not contained in white light, but is produced as a result of the mingling of light and darkness. He reasons further: How can white light be composed of colored lights when every color is darker than white? To obtain color there is necessary an intermingling of light and darkness; the color nearest the light is yellow, that nearest darkness is blue. Mix the two and green results. Blue tends to become red through violet, and yellow tends to become red through orange. These and many more observations and conclusions of interest convinced Goethe that colors are produced by mutual influence of light and darkness; the prism only served to move light and darkness over each other.

The fundamental error in Goethe's interpretation is this: whereas white light to him is homogeneous, Newton's is composed of many darker lights. As Newton had demonstrated in a series of simple experiments when he was a student at Cambridge, a beam of light from the sun, when passed through a prism casts a spectrum of lights of different wave lengths and corresponding colors. The red, or light of longest wave length, is refracted the least, violet the most. A second, reversed prism may be placed in the beam, and white light will emerge from the second prism. Goethe apparently did not perform this experiment, or he would have been convinced that white light *is* composed of "darker" colored lights. One other observation is of significance in relation to Goethe's theory; namely, that the source of light must be narrow, and the prism so placed in the beam (near the source) that the spectrum when cast upon a screen or wall will not be impure. If the beam of light which strikes the prism is wide, the red rays formed from the basal part of the beam will overlap the blue rays from the beam passing through the top of the prism. The overlapping results in an imperfect spectrum, such as Goethe obtained, showing red to yellow at the top and blue-violet at the bottom, with the central region white. A piece of white paper, for example, when viewed through a prism is colored only at the edges, as Goethe observed, but it is too wide a source of light (reflected) to obtain a pure spectrum. It is necessary to use a pinpoint beam of light, which might be represented as a single line of light striking one point of a prism.

When contemporary physicists refused his theory the honor of consideration, Goethe requested the French Academy to report on his work, but his request was rejected. With criticism of his observations withheld by those who were best qualified to criticize, Goethe defended his theory of colors rather bitterly and with a certain amount of obstinacy to the end of his life.

It is significant that Goethe's one failure in the field of science also represents his one departure from the method of synthetic thinking. He had no aptitude, nor even interest, in mathematical analysis of phenomena, and this contributed much to his failure to derive from his observations a correct understanding of light and color. But great respect is due Goethe's accumulation and systematization of facts and observations; and the artists of the period, concerned mainly with qualitative knowledge of colors as perceptions rather than as physical phenomena, derived a great benefit from the *Farbenlehre*. Even today, when one reads the monograph, one is struck with the fact that Goethe's explanations of his observations constitute a monument to ingenuity.

Goethe was fortunate in possessing the combination of a brilliant mind, the broadest natural interest in things, and the accident of living at the threshold of a great scientific era. For not only was Goethe one of the greatest contributors to the world's literature, he was one of the few men possessed of the kind of thinking necessary to bring to science an entirely fresh point of view. He lived at a time when science was turning from the purely descriptive era to one in which synthetic thinking produced the first great concepts in the realm of biology. Goethe was endowed with the ability and the zeal to be one of the first great contributors: in zoology, the vertebral theory of the skull; in zoology and botany, the comparative method; in botany, the doctrine of homology; and in biology, although not credited with a part in it, he was one of the contributors, before Darwin, to the concept of organic evolution. Because these contributions belong to all mankind, a mind like Goethe's *is* the common property of all nations.

STRATEGY, ECONOMICS, AND THE BOMB

JOSEPH E. LOFTUS

Formerly economic adviser at the Office of Economic Stabilization and at the Office of War Mobilization and Reconversion, Mr. Loftus is now Director of the Teaching Institute of Economics at the American University, Washington, D. C. During the past year, the Institute has concentrated its resources on an extended examination of the economic aspects of atomic energy utilization. This paper is one of a series of studies developed in the course of the Institute's work.

THE publication of Professor Blackett's book *The Military and Political Consequences of Atomic Energy* last October in London, and the subsequent American "translation" under the title *Fear, War, and the Bomb,* has elicited wide attention and comment. The volume of book reviews in the past few months has been so large that a reviewer, at this late date, can quite safely assume that his readers have at least read enough reviews—if not the book itself—to be quite familiar with the general thesis of the book, its method of analysis, the main evidential materials of the analysis, and the general conclusions.

Accordingly, this review will not spend limited space on another summarization of the contents of the book. Nor will it concern itself with an analysis of its political arguments, or the general conclusions and recommendations of Professor Blackett. Rather, this review will limit itself to a detailed examination of three themes which, on the one hand, are fundamental to Blackett's position, and which, on the other hand, have not been scrutinized too critically or carefully in the reviews published thus far. These three themes are: (1) the emphasis on the employment of "numerical or statistical" analysis in military and economic problems, (2) the imputed importance to Russia of atomic energy as a source of electric power, and (3) the effort to deflate, in the light of World War II experience with large-scale aerial bombardment, the generally held opinions on the tactical and strategic consequences of the A-bomb.

ON QUANTITATIVE ANALYSIS

In the introduction to his subject matter, Professor Blackett emphasizes the importance of "numerical or statistical" reasoning as opposed to "qualitative" reasoning in considering the military and political consequences of atomic energy. He summarizes his own predilections in this respect with a quotation from Charles Babbage: "Nor let it be feared that erroneous deductions be made from such facts; the errors which arise from the absence of facts are more numerous and more durable than those which result from unsound reasoning respecting true facts." It is not just a flippant digression to point out that this opinion of Babbage's was not arrived at by a numerical or statistical comparison of the number and durability of errors obtained by the one method as against the other! It is purely and simply a qualitative value judgment of precisely the sort that Professor Blackett is in principle complaining against.

To the extent that Professor Blackett, in this emphasis on quantitative reasoning, means simply that what is required today in the conduct of human affairs is less hysterical and emotional thinking and more—much more—realistic and sober thinking, one must thoroughly agree with him. To the extent, however, that he means that there is an intellectual process called "numerical or statistical" analysis as opposed to, and distinct from, "qualitative" reasoning, one must vigorously disagree with him. One must disagree even more vigorously if he means also that there is something objective and conclusive per se about what he calls "numerical" reasoning. The blunt fact of the matter is that in dealing with social science and military science data, quantitative and qualitative are inseparable. The manipulation of quantitative data requires not less but more exercise of the highest order of qualitative reasoning from beginning to end, from the initial determination of the statistical categories into which the data will be sorted to the final interpretation of the numerical results.

This point cannot be emphasized enough in view of the fact that there prevails in our age an unhappy inclination to identify facts and figures

with objectivity. Professor Blackett's convincingly written discourse on method in the preface, coupled with his impressive use of facts and figures throughout the book, may lead the unwary into believing that subjective and qualitative considerations are at a minimum, when really they are not.

Lest this appear to be quibbling over a methodological nicety, one somewhat extended illustration is worth while exploring.

All of Professor Blackett's analysis of the effectiveness of the atomic bomb, in terms of the experience of the bombing offensive against Germany, hinges upon the proposition that there is a rough rule-of-thumb damage equivalence between the atomic bomb and ordinary high-explosive bombs. The equivalence is of this order: 2,000 tons of ordinary bombs equal one Nagasaki-model atomic bomb; 3,000 tons of ordinary bombs probably equal one improved-model atomic bomb. Now in the technical discussion (pp. 44–46), Professor Blackett correctly, but quietly, states that this equivalence holds true providing the ordinary bombs are *properly distributed over the target.* Nowhere does he examine the problem of what are the real difficulties, the real probabilities, in an actual bombing situation of obtaining this sort of "proper distribution." Even more important is the fact that in all other parts of the book where this rough principle of damage equivalence is applied, not a single reference is made to the "proper-distribution" assumption.

That this is most important can be demonstrated from just two typical case studies from the USSBS reports. Monograph Number 71 in the European Theatre Series of the USSBS studies[1] describes in some detail the bombing effort that was made to eliminate the Hermann Goering Werke steel plant near Hallendorf. The buildings and equipment of the plant were generously spaced over a 1,200-acre plot, although the main installations (i.e., the coke plant, the blast furnaces, the steelworks, the rolling mills, and the 360,000-KVA powerhouse which supplied not only the steel plant but also a substantial amount of power to the industrial economy of this area of Germany) were located in the center of the site, covering an area less than two thirds the size of the total site area.

During the course of the war, this plant was raided twice in 1941, twice in 1943, fifteen times in 1944, and twice in 1945. Accurate bomb tonnage figures were available for only four of these raids; but since this plant was never a priority target it can safely be assumed that through the end of 1944 the tonnages would have been so light as to have caused no significant damage. That this is a prudent assumption is indicated by the fact that the tonnage dropped on December 17, 1944, was only six tons! Accordingly, it is not unreasonable to assume that the bulk of the damage that was done to the plants was done during the 478-ton raid of January 14, 1945, and the 253-ton raid of March 29, 1945.

Although it would be interesting to discuss in detail the nature of the damage done, the important point to be emphasized is that despite the fact that both these raids were conducted in midafternoon at a time when the air forces had complete control of the air, no "proper distribution" of the ordinary bombs was achieved. For example, in the big January raid, out of some 3,190 high-explosive bombs dropped (mainly 500-pound bombs), only 1,200—much less than half—fell within the total plant area, and the bombs that did fall within the plant area were neither spread evenly and symmetrically over the whole area nor concentrated at the main vulnerable points. What was in fact obtained was a random scattering of bombs all over the site. The powerhouse, coke plant, and the ore preparation plants, which offered "the greatest opportunity for disrupting operations with the smallest direct bomb effort," were not severely damaged.

Picture the results in the same 1,200-acre plot if an atomic bomb were dropped anywhere in the center of the large triangle formed by the powerhouse, the steelworks, and the second battery of blast furnaces—or, for that matter dropped, within limits, outside the periphery of the 1,200-acre plot. It is a significant point, though not mentioned at all by Professor Blackett, that the A-bomb when used in precision bombing of key industrial and military targets has greatly extended the destructive range of "near-misses." The atomic bomb literally provides a new connotation for the old boyhood taunt, "A miss is as good as a mile"!

The second case study that illustrates the unreality of an easy assumption of "proper distribution" of ordinary bombs is taken from Monograph Number 185[2] of the USSBS series on the European Theatre. This monograph describes in detail the bombing offensive against the Synthetic Oil Plant at Meerbeck-Hamburg, Germany. The plant was one of the largest Fischer-Tropsch process plants in Germany, and, although it accounted for only 1.7 percent of Germany's synthetic oil production, was an important producer of mixed and light Diesel oil, *Triebgas,* and gasoline.

As a target, this plant was located on an even smaller land area than the Hermann Goering plant at Hallendorf. All the buildings were concentrated close together on a trapezoidal area covering but 100.8 acres. Despite the relative smallness of the land area of the target, it was found necessary, during the war, to drop a total of 7,403 tons of high explosives on the target. Of this total, 6,343 tons were dropped during the intensive attack period, July 20, 1944, to November 20, 1944.

The plant, of course, was completely destroyed by the end of the intensive attack period. The significant point is, however, that of the 7,403 tons dropped, the USSBS was able to find evidence of only 116 tons of bomb hits in the plant area. Or, stated another way, of 19,126 bombs dropped, only 328 fell within the plant area. Only a vigorous effort finally obtained the distribution of bombs over the target area that was required to render it inoperative.

With the plant located in such a small area (100.8 acres), one atomic bomb dropped anywhere in the area, or anywhere outside the area for a considerable distance beyond the periphery, would have accomplished the same physical destruction with considerably less total effort.

Detailed examination of the bomb plots and the analyses of air raid damage contained in the USSBS individual monograph studies of sixteen German cities subjected to heavy area bombing eloquently testify that it is a most difficult task to obtain a "proper distribution" of ordinary bombs.[3]

To summarize, Professor Blackett has based a substantial part of his elaborate "numerical" analysis of the number of atomic bombs required to accomplish the same amount of damage inflicted on Germany by ordinary bombs on the principle of equivalence that one new-style atomic bomb equals 3,000 tons of high explosives properly distributed over the target. His failure to adjust his "numerical" application of the equivalence principle to take account of the fact that one of the reasons that such great amounts of high-explosive bombs were required was the enormous difficulty of obtaining a proper distribution of bombs, represents on his part a qualitative judgment (or lack of it!) that raises some serious questions as to the validity of the conclusions of some of his extended quantitative analyses.

Other and more important instances of the same sort of thing will become apparent in the subsequent discussion of Professor Blackett's analysis of the economic and military implications of the atomic bomb. The caution to be emphasized, for the moment, is that in reading Blackett one must ever be on the alert to avoid mistaking statistical arguments for objective arguments. It must be recognized that the making of significant qualitative assumptions is inescapable in the process of assembling and interpreting numerical data. It is these qualitative judgments that ultimately determine the validity and the significance of the numerical results.

THE ECONOMICS OF THE BOMB

In a somewhat brief chapter entitled Power From Atomic Energy, Professor Blackett attempts to establish the argument that one of the significant contributory causes for the breakdown of negotiations for an international agreement on the control of atomic energy has been—and will continue to be—the disparate importance of atomic energy as a source of electric power in the USA, a power-rich country, and in the USSR, a relatively power-poor country.

The argument, cleansed of the exaggerated—and unnecessary—digressions on the motives of certain people and groups in the USA, can be summarized as follows:

1. The industrial strength of any modern nation (and thus, also, its standard of living and its military potential) depends on the availability of electric power;
2. But historically there has been a wide disparity in the levels of energy production and consumption in the USA and the USSR—the former in 1935 consuming six times as much energy as the latter;
3. Now, atomic energy shows bright promise of providing a new source of electric energy, with unique and attractive physical and cost characteristics.
4. In a world *without* international regulation of atomic energy, therefore, the USSR would in all probability exploit the development of atomic energy for industrial purposes at a faster rate and in greater magnitude than the USA because she has a much greater incentive to do so.
5. But, in a world *with* international regulation of atomic energy (a la Baruch), the USSR would be prevented from exploiting atomic energy for industrial purposes at the speed and to the extent that she otherwise would in an unregulated world. This, Blackett contends, would hold true regardless of whether in the international regulation arrangements the allocation of primary generating plants were done by an initial binding treaty or by a series of *ad hoc* decisions by an international regulatory commission. If the former, the treaty would have to allocate primary plants according to a formula that would preserve the "strategic balance" among the great powers, thus perpetuating the existing energy disparities as between USA and USSR. If the latter method were adopted, the USSR would always be a minority member of such a commission. As such, she would always have to fear discrimination by the majority; the best she could hope for would be the sort of automatic treatment resulting from a decision of the committee scrupulously to pursue a policy of preserving the "strategic balance."

At first glance, the argument sounds most plausible and convincing. Upon close scrutiny, the argument can neither be substantiated nor refuted. Too many unknown factors are involved. The strongest statement that can be made is that this is a *hypothesis,* not an argument, that merits much more analysis and *quantitative* study. As the life of the world's economies unfolds in the future, the hypothesis may eventuate to have been correct; but there is no governing consideration for accepting it now. If anything, the very meager evidence available now suggests either rejecting the hypothesis or initiating in the UNAEC an extended quantitative inquiry on the problem—the sort of inquiry that Professor Blackett pleads for in his introductory chapter but does not provide in this chapter!

Despite the present paucity of good evidence, certain relevant observations can be made that will be useful in assessing the merits of Blackett's economic argument. The first set of observations concerns the differences in the national incentives of the USA and the USSR to develop and assimilate atomic energy into their economies.

In general, it may be stated that Professor Blackett tends to underestimate not only the incentives of the USA, but also, peculiarly enough, the incentives of the USSR. With respect to the latter, it is true that Russian energy consumption is roughly one sixth of American levels. Much more important, however, is the fact that in terms of estimated per capita energy potentials, the USSR has only about 60 percent as much potential energy from conventional sources as this country. Most important is the fact that, even though in the aggregate the USSR has sufficient potential energy to provide her people with a per capita consumption equivalent to current USA levels, certain economically important regions of the USSR have inadequate and uneconomical power resources. A few conspicuous illustrations of this are pertinent.

In the southern Urals, Sverdlovsk, Chelyabinsk, and Magnitogorsk (the Russian Pittsburgh) constitute an industrial triangle tha represents one of the key areas in the Russian economy. Within this triangle are located rich supplies of iron ore, copper, nickel, cobalt, bauxite, potassium, and salt, but poor and inadequate supplies of fuel and power. Coal, the *sine qua non* for development of the rich industrial resources of the region, has to be transported over seven hundred miles from Karaganda and Kuznets. Clearly, in such a resource context, atomic energy electricity, if cheap enough, would be a boon.

In the northern Urals, Bogoslavsk has rich bauxite deposits and is currently the heaviest aluminum-producing region in the USSR. This same region, however, is lacking in adequate power resources. The nearest hydro stations are beyond the range of economical transmission of power and, worse still, are located in a temperature zone where the rivers freeze over in winter. Necessarily, then, bauxite is reduced to aluminum by coal. In such a situation, a completely integrated aluminum operation based on cheap atomic power would be highly desirable.

The situation in industrial Leningrad is much the same. Leningrad has a large supply of peat but inadequate supplies of other fuels. Thus it is necessary for Leningrad to import coal distances of over a thousand miles. Clearly, atomic power, if cheap enough, could greatly benefit such an area.[4]

There can be little question, therefore, about Professor Blackett's assertion that the incentives for pressing forward the development of atomic power are strong in Russia. In fact, the incentives, considered by themselves, are stronger than he indicates. Offsetting these incentives, however, are several other important factors which would have to be taken into account by the USSR in making any final determination to press forward with the development and assimilation of atomic power into its economy.

The first such factor is an important military consideration. If, because of the absence of international regulation of atomic energy, the USSR were successful in quickly developing atomic energy as a cheap source of electric power, she would be early confronted with the problem of making a difficult decision between the economic advantages and the military disadvantages of locating atomic energy power plants in the industrial areas where it would be most needed. In the case of important industrial areas like Leningrad, Bogoslavsk, and the Chelyabinsk-Sverdlovsk-Magnitogorsk triangle, cheap atomic power would be a tremendous economic advantage. But for at least two reasons it would constitute a sizable military disadvantage. In the first place, it is clear that, with or without atomic power, the critical objective of attack in any future war will be the atomic energy industry of the enemy. The destruction of an enemy atomic energy installation would constitute an important reduction in the enemy's capacity to produce atomic weapons. The target, of course, would be doubly attractive if the atomic installation, in addition to making weapons material, were also the base supplier of energy to such

strategic industries as steel, aluminum, etc. For this reason, in a bipolar world ungoverned by atomic energy controls, the USSR would have to be extremely cautious in increasing its economic and military vulnerability by gearing its power-poor industrial areas to an atomic energy power base.

Quite apart from the problem of vulnerability would be the additional risk of having plutonium supplies for an atomic power station curtailed in time of war. Until such time as plutonium is in extremely long supply, the USSR will always have to face the possibility during a war of allocating all its plutonium supplies to weapons, even if this should entail closing down its atomic power plants. In view of this, the USSR will have to be extremely cautious in adapting its important industrial areas to a power base that it might not be able to supply without interruption.

A second factor that might tend to restrain the rate at which the USSR would develop atomic power would be the cost of the effort in terms of the other projects which have a high priority in their development effort, and in terms of what burdens the economy can stand at a given point in time. Measured in units of skilled manpower, or in units of critical materials, any rapid and extensive development of atomic power by the USSR alone would be an extremely costly proposition.

When these limiting factors are combined with the positive incentives the USSR has for developing atomic power, no clear picture emerges. At best, the Soviet Union will have to make a difficult decision between the economic advantages of cheap power and the military disadvantages. It is not inconceivable that it is the recognition of these limiting factors that prompts the USSR to make less of an issue at UN of the power implications of atomic energy than does Professor Blackett. For, Blackett's analysis notwithstanding, the curious fact is that in general the USSR delegation has been congenial to the idea of using quotas in controlling peaceful atomic activities.[5]

With respect to the USA, Professor Blackett again underestimates the incentives. In the first place, although this country is now at a uniquely high level of per capita energy consumption, there is evident no clear indication that the persistent historical surge toward higher and higher levels of per capita consumption will die down. The trend toward greater utilization of electricity-consuming equipment in the home, on the farm, and in the factory continues strong.

Second, the USA per capita annual consumption of energy is beginning to press upon its estimated per capita annual potential energy output. Currently, the USA is consuming, on a per capita basis, roughly 30 percent of the energy it could produce if its potential annual per capita output were completely exploited. The corresponding figure for the USSR—unadjusted upwards for recent territorial changes—is in the neighborhood of only 10 percent. Although even a figure of 30 percent at first glance looks so low that there need be no concern for seeking new sources of electric power, the fact of the matter is that, when you take out of the potential figure all the high-cost and locationally unattractive potential energy sources, the 30 percent figure becomes significantly higher. In short, for the long view, even taking into account the effect of a declining population, but assuming the continuance of the tendency to consume ever-increasing amounts of power, the USA has a considerable long-run incentive to develop atomic power as a significant supplementary source of energy.

In this connection, Professor Blackett might argue that even if this were true this is something for the future, and that since the USA is not accustomed or capable of taking the long view, such a future prospect would not constitute an effective incentive to the early and quick development of atomic power by the USA. Such, certainly, is the implication of his discourse on the disposition of the USSR to take the "long view" (p. 110), and the intent of his several references to the pressure groups within the USA that are hostile to the development of atomic power. It may be that Professor Blackett's opinion will prove to have been a sound appraisal of the American scene. Sadly enough, the fragmentary evidence there is suggests that he may be right; happily, however, it is not conclusive. There are sufficient forces at work in the economy for one to be hopeful that this country will take the long view as it has in other contexts in the past.

A third consideration respecting USA incentives that Professor Blackett completely neglects is the impact of atomic power on the American economy in the absence of any substantial international regulation of atomic energy. Let us suppose that the present impasse between the USA and the USSR should continue. Suppose further that the impasse should continue to be characterized as it now is by: (*a*) chronic war scares, (*b*) high armament expenditures, and (*c*) an effort on the part of both countries to achieve and maintain a supremacy in atomic weapons. If such a situation persisted long, it is not unreasonable to conjecture that the American people, burdened on the one

hand by a heavy tax rate, and impressed on the other hand by the use of atomic energy as a source of electric power, might insist on the conversion and distribution of atomic power as a means of somewhat reducing the net cost of the high national military budget. If such eventuated, the USSR—doing the same thing—would gain in its absolute level of energy utilization but would not gain in reducing the existing disparity between the levels of utilization in the two countries.

On the whole question of incentives, then, little of a really conclusive nature can be said. The USSR clearly has sizable incentives, but these incentives are circumscribed by serious limiting considerations. The USA may have less compelling incentives, but what incentives she has are less diluted by limiting factors.

Even assuming, however, that somehow or other the USSR should have more intense incentives, in the final analysis the extent to which the one economy or the other will or will not embrace atomic power will depend on the cost of such power in a given situation relative to the cost of obtaining power by alternative means.

In commenting on some opinions that have been expressed on the possible economic gains of atomic power in different countries, Professor Blackett wisely asserts that

> The sounder way of estimating the potential gain to any country from increased power supplies is to calculate the total social cost, not of replacing its existing power supplies by atomic power, but of raising them to the level found necessary for the attainment of an adequate living standard. . . .

This is correct but incomplete. The sound way of estimating the potential gain to any country is to calculate not only the cost of its marginal supply of power, but also the comparative cost of obtaining that additional increment from all other energy sources. Thus for a given new addition to the power supply of a country it is necessary to calculate and contrast the probable cost of that increment if produced by atomic power, if produced by the most efficient hydro plants, if produced by the most efficient steam plants, and so forth. Atomic power, say, twenty years from now, will be adopted in any particular economic locality only if the net cost of so producing power is equal to, or less than, the cost of producing power in that same area by the then most efficient style steam stations or hydro stations or any other process for producing power.

The figures which Professor Blackett cites from Mr. Schurr's study are of little help in making such a calculation. Indeed, as they are used by Blackett, they tend to be misleading. For example, even if the Thomas estimate of 8 mills for atomic power should eventually prove to be correct, there is no reason to think that this figure would be the same in all countries of the world. This is a most plausible conjecture to make if one assumes that atomic power will be developed outside the framework of an International Development Authority. Because of the fact that atomic power will involve large capital costs, the unit cost of power from atomic energy in any country is going to be seriously influenced by the cost of money in that country. Other factors, such as differences in salary scales for skilled technicians, differences in construction costs, and variations in the demand for electricity, will tend to produce variations in the total unit cost of atomic power in different countries. For example, in the case of Argentina, it would not be impossible that because of factors such as these the cost of atomic power there would be 19 mills as contrasted to an 8-mill atomic power cost in the United States. In such a situation, Argentina would make her decision to construct atomic plants on a comparison of the 19-mill figure with the cost of producing power from the then existing most efficient alternative methods of generating power.

If the figures on atomic power costs as used by Professor Blackett are unintentionally misleading, his use of the figures on generating costs for Argentina, Great Britain, and the USA is surprisingly careless. Despite the fact that Mr. Schurr, in his article, took pains to point out that these cost data are not actual generating costs, but rather are costs estimated from the cost of fuel in various regions, Professor Blackett in quoting them states that they are "actual average cost[s] of electricity" (p. 108, Table 3).

This, by way of digression, is a good illustration of the importance of recognizing always the qualitative foundations of a quantitative analysis that was referred to in the earlier paragraphs of this paper. Mr. Schurr chose to use estimated costs rather than actual average costs for a quite sound reason. Had he used average actual costs, his final cost figure would have had an upward bias because the average figure would reflect the costs not only of the latest and most efficient plants but also the costs of the old, obsolete, and inefficient plants. Since reliable figures on costs of the most efficient plants were not available, he adjusted the costs of a modern 100,000-kilowatt plant as described in the December 2, 1939, issue of the *Electrical World* to reflect variations in the cost of fuel in different areas. To the extent that there have been techno-

logical improvements resulting in cost reductions since 1939, the figures overstate the costs of generating electricity in the several countries. To the extent that there have been changes in the net cost of coal, the generating costs have an upward or downward bias depending on the direction of the movement of coal and transportation prices.

What Mr. Schurr has done is ingenious, yet legitimate. It must be recognized, however, by anyone using the figures to demonstrate a given point that the validity of the figures is necessarily limited to the validity of the qualitative assumptions that went into their original composition. This Professor Blackett has neglected to do.

Much more could be said on the question of the comparative costs of atomic and conventional power. The main points to be stressed here, however, are simply these two. First, the studies so far available are too fragmentary, too conjectural, to be used for reaching firm policy opinions that atomic power would be more economical in one region than in another. Second, it is of the utmost importance that economists exert a more vigorous and extended inquiry into the power aspects of atomic energy. The work of Schurr[6] and Isard[7] is a sizable contribution; but measured against the amount of knowledge that is required if wise policy decisions are to be made, it is insignificant.

One last word on Professor Blackett's analysis of the power implications of atomic energy is in order. Although he describes in some detail the power poverty of India, China, and other backward economic areas, he fails to consider how in fact such countries would benefit by atomic power in a world without an International Development Authority. At best, he implies that by some mysterious process, power-poor countries possessing indigenous supplies of uranium and thorium would produce atomic power.

But such is not the testimony of history. Kuwait, with her rich petroleum deposits, has always been a power-poor country; so also Alaska, despite of her extensive coal deposits; and so also the Belgian Congo, despite its abundant hydro potential. Less dramatically, countries like most of those in the Latin-American bloc have not significantly exploited their limited energy potentials.

In all probability, availability of fuel resources is a relatively unimportant factor in national economic development. Availability of capital, climatic conditions, political stability, the cultural texture of the inhabitants—all these and many other factors influence the rate of economic development in a given country. Left to themselves, the backward economies of the world will probably have their relative energy positions worsened rather that bettered by atomic power.

This, however, would not have to be the case if atomic power were developed on a cooperative international basis. In the financial resources and in the technical knowledge of an International Atomic Energy Development Authority resides a real hope for the backward areas of the world. The same holds true for the more developed areas which lack adequate power resources and capital: France, Italy, Japan, and even England.

It is an unfortunate thing that thus far this aspect of international control of atomic energy has not been sufficiently emphasized. Too much emphasis has been placed on the necessity of international control as a mutual protection against atomic warfare; too little attention has been given to the great positive possibilities for improving the standards of living of the countries of the world that are inherent in an International Atomic Energy Development Authority. It is to be hoped that the current discussions at UNAEC on such questions as the use of quotas and the financing of an international authority will bring out in clear light this important point.

In this connection, it is not easy to appreciate Professor Blackett's low estimate of the "generosity" of the Baruch proposal. Considering the preponderant financial, technical, and personnel contribution that this country would have to make to an International Development Authority, Professor Blackett does not establish too convincing a case that the American proposal is ungenerous.

THE MILITARY ASPECTS OF THE BOMB

The backbone of Professor Blackett's book, of course, is the analysis of the strategic and tactical consequences of the atomic bomb. Starting from the prudent position that in order to assess the effects of atomic bombs in future wars, one must begin with as sound and detailed knowledge as possible of the effect of atomic bombs and weapons of comparable destructiveness in the past, he proceeds to an extended review and appraisal of the performance record of aerial bombing efforts during World War II. Since there is available only the wartime experience with two atomic bombs, released under quite exceptional circumstances, the bulk of experience analyzed is in terms of the enormous conventional bombing effort over Germany and Japan.

In studying the analyses of the air offensives against Germany and Japan, as contained in the five summary volumes of the USSBS, Professor Blackett observes that the significant fact is that

a huge weight of bombs dropped on Germany did not lead to a failure of either production or civilian morale. From this observation, he makes two important deductions: (1) since 3 million tons of bombs were dropped by the Anglo-American air forces on German and Japanese targets without decisive effect, it is certain that a very large number of bombs would be needed to defeat a great nation by bombing alone; and (2) in any future war between the USA and the USSR, the conflict would not be decided by atomic bombing alone, or in a short period of time. On the contrary, he contends, there would ensue a protracted, bitter struggle spread over much of Europe and Asia, involving million-strong land armies, huge military casualties, and widespread civil war.

Earlier in this review, the point was stressed that quantitative analysis necessarily involves the making of significant qualitative judgments. Professor Blackett's extended numerical treatment of the Anglo-American bombing offensive against Germany is another sad illustration of how qualitative judgments, however hidden they may be, determine the whole numerical outcome. For reasons known only to himself, Professor Blackett has chosen to evaluate the effectiveness of strategic bombing in terms of the total tonnage dropped from 1940 to 1945 considered as an aggregate, rather than as a series of periods in which strategic bombing as an instrument of warfare was being progressively perfected. Given this qualitative decision, it was inevitable that he should arrive at his conclusion that the Anglo-American air forces received a relatively small dividend in return for their investment of over a million and a third bomb tons dropped on Germany. Thus, also, the inevitability of his conclusion that over four hundred improved atomic bombs would be required to inflict comparable damage.

The fact of the matter is, however, that so important were the lessons learned in the course of five years that any substantive similarity between the strategic bombing of 1940–43 and the strategic bombing of 1944–45 is of only a nominal nature. The developments were not simply in the nature of improved planes, bombsights, long-range fighter bombers, navigational aids, and photographic interpretation; fundamentally, the most important development was a realization of the strategic character of strategic bombing.

The basic resources of an economy are its industrial capital equipment, its industrial manpower, and its supply of raw materials. For strategic bombing to have a decisive effect, it is essential that the bombing be directed at the most vulnerable points in these basic resources. Largely out of desperation, but partly out of bad judgment, the British Air Command chose in the early years of the war to attack that German basic resource which was the least vulnerable but the most accessible, namely, German urban manpower.

The choice was unwise for at least two reasons. In the first place, Germany at the beginning of the war through to at least mid-1944 had more than ample manpower reserves. A large native labor supply, supplemented by sizable increments of foreign labor, provided the German economy with adequate insurance against almost any conceivable high casualty rate from area bombing. In the second place, the labor supply that was concentrated in the cities subjected to area bombardment did not contribute greatly either to total Reich production or to total Reich war production. For example, Augsburg, Bochum, Leipzig, Hagen, Dortmund, Oberhausen, Schweinfurt, and Bremen—cities that were the targets for severe area attacks—contributed to total Reich industrial production in very small percentages. In the order named, the contributions of these cities were: 0.3 percent, 0.9 percent, 1.7 percent, 0.3 percent, 0.9 percent, 0.5 percent, 0.2 percent, and 1.2 percent.[3] With the exception of the iron and steelworks at Dortmund, and the aircraft plants at Bremen and Leipzig, none of these cities were significant producers of war material.

A later choice by the Air Command to attack aircraft production centers was as imprudent a decision as that to attack urban centers. Aircraft production in Germany was a highly decentralized and deconcentrated operation. Planes were produced in many plants spread throughout the land—plants that were of modern type, well camouflaged, and constructed with a view to minimizing the damage effect of bombs. As a direct target for air bombardment, it was a highly invulnerable sector of the German war economy.

Despite the fact that because of its resource base Germany was not an easy target, there were at least three points of great vulnerability: her power system, her synthetic oil industry, and her transportation system.

The first-mentioned vulnerable point, much to the wartime surprise and the postwar delight of the Germans, was never a high-priority target. The tightness of power supplies, on the one hand, and the frangible nature of most power-generating and -transmitting equipment, on the other hand, were never adequately understood by Allied air intelligence. Hence, this crucial target was unfortunately overlooked. Had it not been, much

greater returns could have been achieved by the air offensive for an infinitesimally smaller investment. For example, officials of the Berliner Staedtische Elektrizitaetswerke A. G. have stated

> that if the power plants of Klingenberg and West had been destroyed by bombing, the industrial life of Berlin would have come to a complete standstill. Not even the outside national networks could have supplied sufficient power without seriously curtailing the consumption in other parts of Germany.[3]

The significant fact is that 50,412 tons of bombs dropped on the city as a whole never achieved the industrial paralysis that a few hundred tons dropped on two electrical plants would have. By Professor Blackett's calculus at least sixteen improved atomic bombs would have been required to obtain the same limited industrial paralysis of Berlin that was in fact obtained. The more significant calculus is that two atomic bombs placed anywhere within a wide near-miss radius of the two power stations would have brought the industrial life of Berlin to a complete standstill. The weapon assumes an even more formidable appearance if one considers the radioactive effect of an atomic bomb detonated much closer to ground zero than was done at Nagasaki.

Because of her lack of indigenous supplies of petroleum, Germany was precariously dependent upon her synthetic oil production. Despite her invulnerable capacity to produce planes and tanks in large numbers, the final determinant of how many she could effectively put into battle rested with her synthetic oil industry. The complete destruction of her synthetic oil capacity, after allowing a time lag to account for the exhaustion of accumulated reserve stocks of processed oils, spelled the end of the German war machine. An investment of less than two dozen atomic bombs well placed could have rendered the German war machine inoperative after the expiration of the short time in which it would have used up its reserve stocks.

In this connection, Professor Blackett erroneously attributes the late mounting of the air offensive against the synthetic oil industry to the necessity of the Allied command waiting until it had advanced German bases and air superiority. Actually, a good part of the delay was caused by the long time it took the Air Command to learn the decisive strategic importance of oil in the German war economy.

The third soft spot in the German economy was her transportation system. Since coal was the key to German industrial production, war production of tanks, munitions, and so forth could have been as effectively stopped by the interdiction of the transport system as by a much, much larger effort at destroying all the individual plants producing finished goods. Once this was realized by the Air Command, extensive raids on concentration yards, bridges, tunnels, and rail bottlenecks were launched. Eventually, this effort was successful in so reducing coal shipments that industrial production came to a standstill in many areas.[8]

It is difficult to speculate on the effectiveness of atomic bombs on the transportation system of a country. The USSBS study of Hiroshima and Nagasaki is anything but informative. From the meager evidence available it would appear that atomic bombs might be quite effective against concentration yards; their effect on tunnels, and especially bridges, would seem to be negligible. This is not merely of academic concern for at least two reasons: (1) experience in Germany suggests that the destruction of bridges was the most effective single way of disrupting rail movements for significant periods;[8] and (2) in both the USA and the USSR the transport systems are highly vulnerable points of the economy. This is especially true of the USSR.

The experience with mass bombing in the European and Pacific theatres has several important lessons that can be briefly summarized. In the first place, for strategic bombing to be strategic in the literal sense of the word, and effective in terms of military consequences, it needs must be directed at those points in the economy of the enemy that are most vulnerable, those points that if destroyed would bring about disproportionately larger disruptions of the economy and war machine as a whole. What those vulnerable points will be for a given country depends upon the structural specifics of that economy. For example, in the USSR, considering her industrial dependence on coal and the large distances that coal would have to be moved over inadequate transport facilities, a high-priority target in a rational strategic plan would be the interdiction of her rail network. Like Germany, the USSR has a highly invulnerable aircraft- and tank-production capacity; thus, only a larger bombing effort than makes sense would be required to reduce such production. Somewhat like this country, USSR steel production tends to be concentrated in one area—Magnitogorsk—thus providing a highly attractive target for strategic bombing.

A second and more important lesson is to be derived from the World War II experiences. It seems fairly clear that urban area mass bombing

would be employed in a future war in three different contexts: (1) as a "what-else," desperation effort to achieve decisive effects at the outset of a war; (2) as a by-product result of the precision bombing of a key industrial installation located within or near the periphery of a city; and (3) as an effort to hasten the conclusion of a war after the industrial capacity of the enemy to continue the war has been destroyed. This was the rationale of the urban attacks on Japan by conventional bombs and atomic bombs in the closing months of the war.

With respect to the first context, one must agree with Professor Blackett that this sort of effort would in all probability not be made in a future war. Recognizing the passive defense opportunities available, the absence of the surprise element of Hiroshima and Nagasaki, the futility of manpower annihilation against a nation with substantial manpower reserves, it is difficult to conceive of the generalship of either side of a conflict wanting to engage in such a grim, futile business at the beginning of a war.

Allowing, however, as Professor Blackett does not, for the facts: (*a*) that generalship is not always rational, and (*b*) that the radiation effects of atomic bombing are not sufficiently known for one to have firm judgments, one must admit there is more than just a slim possibility that such an endeavor would be made by one side or both. If such were the case, the USA would be at a disadvantage because of its greater urban population concentration and its lesser total manpower reserves.

It should be pointed out, however, that Professor Blackett tends to underestimate the degree of population concentration and urbanization in the USSR. For example, in discussing Dr. Oppenheimer's statement that it is not inconceivable that United States air squadrons could eradicate 40 million people, Professor Blackett asserts that to do this "many of the targets would be quite small cities with many less than 40,000 people in them" (p. 72). In other places he speaks of Russian "towns"—the clear implication being that there is relatively little urbanization in the USSR in the American sense of the word.

Such, however, is not the case. In 1939, somewhat over 34 million people lived in Russian cities of over 50,000 inhabitants. Eleven cities, with an average population of 1.1 millions had populations of over 500,000 inhabitants; 71 cities, with an average population of 200,000 people, had populations between 100,000 and 500,000; and 92 cities, with an average population of 73,000, had between 50,000 and 100,000 inhabitants. Or, stated another way, 172 cities with an average population of 198,000 had populations of over 50,000 inhabitants.[10] The comparable figures for the USA are: 197 cities with an average population of 230,000 had populations of over 50,000.[11]

Taking into account the changes brought by the war, the relocation of cities and population, and the increase in population, it is most probable that the degree of population concentration in the USSR is greater than before the war. The rapid rate of industrialization since 1939 would almost necessarily bring about a greater rather than a lesser urbanization.

Although Professor Blackett has established a convincing case that another war in the foreseeable future would not be a push-button war decided decisively in a short period of time, one cannot accept as convincing his conjecture that the next war would be fought by million-strong land armies over much of Europe and Asia. That Professor Blackett can accept this conjecture in view of his own recogniton of the tactical uses of atomic bombs is hard to understand.

A much more plausible forecast is that initially another war would be a struggle for bases, followed by an unprecedented use of air power to cripple the industrial potential of the opponent, and concluded with a bloody annihilation of cities to accelerate the recognition by the enemy that his warmaking capacity had been destroyed.

It should be clearly understood that the reviewer has the same intense feelings as Professor Blackett on the futility and inhumanity of a preventative war. The difference between the two writers is that this one is convinced that a persuading case against a preventative war cannot be made on the grounds that militarily such a war would be difficult, bloody, and of long duration, if not impossible to win. Nations simply do not behave in such a coldly rational fashion. If a preventative war *can* be prevented, it will be because of the recognition by the nations of the world of some governing moral principles, or the unification of the nations of the world around some positive program that promises overriding attractive benefits for all involved.

This rather lengthy review has narrowly limited itself to the military and economic aspects of Professor Blackett's thesis. His political analyses and conclusions, others have and will continue to discuss. When all is said and done, however, one contribution of the book will stand out to its lasting credit. Like no other book on the subject

matter, Professor Blackett's *Fear, War, and the Bomb* has brought clearly to a large number of people the realization of the importance of a wide popular consideration of the politics of atomic energy. In the last analysis, it is the people generally who can and must make the decisions concerning the uses to which this strange force is put. If nothing else, this book has taught many people that without being physicists they can comprehend the political and economic issues of atomic energy.

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SPRING FEVER

Now we pause to look around the world
And wonder, while the cogs stand still or slip
A little; here, behind a greening bush,
We sit up suddenly in the sun to laugh
At yesterday, or frighten squirrels and robins
Fattening with Spring. The hurried April
Steams with meadow-murmur, and prodigious growth
Infolds us; close down to the mouth
Of an osmotic Nature, elbowing damp turf
And gulping like new tadpoles where a musk
Actinomyces odor hovers fresh
And pungent, we rise languidly to face
The apparition of our dignity,
Apprized of time, but laughing at the hour,
And singularly vital to the season.

Henry A. Hoffman

PLANTS AND VEGETATION AS EXHAUSTIBLE RESOURCES

STANLEY A. CAIN

Drawings by Matt Kahn, Cranbrook Academy of Art

Dr. Cain (Ph.D., Chicago, 1930), botanist, Cranbrook Institute of Science, has taught also at Butler, Indiana University, the Waterman Institute, the University of Tennessee, and at Cold Spring Harbor. His article is from an address given in the AAAS Centennial symposium on "The World's Natural Resources" last September.

MAN'S economy has always been concerned with the basic matters of food, clothing, and shelter. The nature of these, their abundance or scarcity, their quality, and their relative cost in money and labor, vary from place to place and from time to time. The condition of man with respect to these basic needs depends upon production and distribution of natural resources derivatives and ultimately, of course, upon the balance between the demands of population and the supply of resources. It is my thesis that whether or not these natural resources can be described as renewable or cyclic they are not quantitatively adequate to permit a continuing consumption at present world rates, and that man everywhere must face squarely the dual problems of the conservation of natural resources and the limitation of population or continue along the path, at an ever-accelerating rate, toward self-destruction.

THE NATURE OF VEGETAL RESOURCES

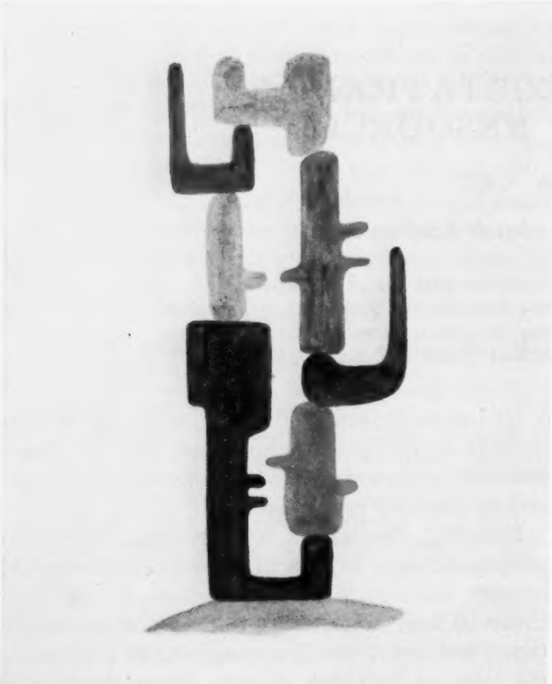
The role of plants in the satisfaction of man's basic needs is unsurpassed by any other natural resource. When we consider the kinds of uses of plants, we find that they are important as energy sources and for nonenergy products. Man's most immediate interest in plants is for sustenance as direct food for himself and, indirectly, as food for the animals that he eats or that do work for him. Much thinking about food (such as measurements of consumption, annual production, and reserves) is in terms of its calories, its energy yield when consumed by the functioning organism. Without implying for an instant that the calorific yield of food can be used as the sole measure, it is important to our natural-resource considerations, for example, that an acre devoted to sugar production yields more calories than several acres devoted to corn-fed hogs, and even more acres used for the production of range-fed cattle. But food serves other functions than that of an energy source. It is through vegetable and animal foods that we obtain the building materials and "regulators" of our constantly renewed protoplasm.

Basically, the human food problem is that of getting enough to eat to prevent physiological hunger; but we are activated scarcely less by psychosocial food hungers. We like to eat at customary times, and our desires for certain foods are outside the logic of nutrition experts. Even though the more favored few may think that other men should moderate their appetites and be satisfied with wholesome plain food, the psychosocial hungers must be considered, as everyone knows whose earnest wife confronts him with a casserole of soybeans.

Plants yield tremendous quantities of energy to man for nonphysiological purposes. In millions of families over the world the home is heated, food is cooked, and water is boiled by the burning of wood or other plant materials. In a smaller number of cases animal fats provide the energy, only a step or two removed from the original plant sources. And what Evelyn Hutchinson has referred to as "fossil sunlight" is yielded to home and industry by the combustion of coal and oil—energy long bound by photochemical processes of plants and not all lost in the vicissitudes of many chemical transformations and many millennia.

When we consider plants and their products in other connections than energy sources, we must be immediately impressed by the thousands of kinds of plants and the myriad of products—most of them manipulated, fabricated, processed, or manufactured—that enter into our housing, furniture, and clothing, into the production of the implements and machines of the means of transportation, communication, industry, business, and recreation.

If we turn our attention now to plants as vegetation, thinking of them not as individuals or kinds



We are here confronted by problems in the balance of nature in what Tansley has called the ecosystem.

but as the communities that mantle the earth, we find ourselves confronted by a more complex situation, and by products and concomitants that are less well understood. We are here confronted by problems in the balance of nature in what Tansley has called the "ecosystem." Nature is particulate and individual in its ultimate structure, but it is organized, and no isolationism is possible. If the ecologists have any single idea that is of importance to man, it is the idea of the wholeness of nature and its communal units. The phenomena of the ecosystem act and interact. The concept of the emergence of complex systems, such as the higher biotic communities, and our holistic interpretation of them, following the philosophy of General Smuts, are products of our increasing knowledge of processes and interrelations, both present and historical.

The point for our present consideration is that man cannot solve in a satisfactory manner any of his natural-resource problems piecemeal without a broad consideration of the unity of the ecosystem. Land classification, reforestation and silviculture on existing forests, range management, watershed protection with all its implications for irrigation, flood control, and wildlife management, the agricultural problems of plant introduction, disease and pest control, crop-type selection and cultivation practices, and a host of other large and small relations of man to his natural world, can only be understood, and wise programs designed and executed, when knowledge of the interrelations of the elements of the ecosystems is both available and used.

THE GROWING DEPLETION OF OUR RESOURCES

Having seen something of the nature of vegetal resources, we return to the basic proposition: Plant resources are inadequate to meet the needs of the world's population, if not now, assuming an equitable distribution were possible, certainly in the near future. Although hunger and even famine are not a new experience to man, especially on a comparatively local basis, such as in one or two provinces of China, the existence or imminence of substandard subsistence levels for hundreds of millions of people on several continents simultaneously is in many ways an essentially modern problem, and it is ironic that this has accompanied recognized advances in our industrial civilization.

Two processes have been accelerating recently at rates that were unknown to man before about a century and a half ago. Beginning with the industrial revolution, and concomitant with the expansion of agriculture onto new lands in the United States and Canada, Australia, Africa, and the USSR, these developments have been, first, a phenomenal growth of population, and, second, an appalling acceleration in the loss of natural-resource capital, especially of fertile topsoils, forests, and waters.

With the industrial revolution have come new means of tilling the soil and of distributing the products of the soil. Society has rapidly changed from various systems of organization based essentially upon a peasantry and subsistence farming to the development of farming as plant industry with specialization in cash-crop surpluses.

Work on the land before the industrial revolution was limited to manpower and horsepower—the energy of food, released by catabolism and employed by muscles. Today, with the power of a hundred horses at their finger tips and with new machines for breaking the soil, cultivating, harvesting, and hauling, and with mechanical saws, bulldozers, and tractors in the forest, fewer men have made the earth yield more resources at a faster rate. There is no quarrel with such technological improvements—the need is for a redirection of effort and a control of the new energy sources, for

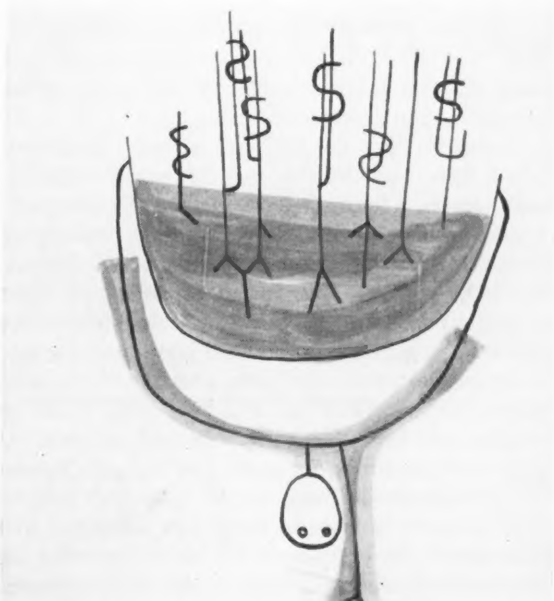
these technological improvements have brought with them undreamed-of complexities. The urbanization of a progressively larger percentage of the population as a whole, including the agriculturists, making living more pleasant, more easy, and more abundant for many, has at the same time made it more complicated, more specialized, and more interdependent.

Yet, despite the complexities of modern-day living, never in the history of man have the conditions been so propitious for an excess of births over deaths. The increased amenities of industrial civilization include more general formal education and more leisure for adult enlightenment. Obviously this may mean, among other things, a knowledge of birth control, which Julian Huxley has considered one of the major achievements of the human intellect, but this educative process also means population increase. Education leads to sympathetic approbation and financial support of research, which in turn leads to better health and better control of disease and pestilence, a lowered infant mortality, a longer useful life, and a falling death rate—this in spite of occasional reductions of birth rate in some localities and for a few special groups of people and the dying out of urbanized families. In general the birth rate has enjoyed a progressive increase through several generations, with the doubling of the world population in less than a century. At present, in the longest-industrialized countries, this unprecedented increase has hit a plateau—indeed, even a failure of women to produce sufficient girl babies to maintain the population at a given level. The waves of industrialization, however, are only now bringing the already populous areas of eastern Europe and much of Asia into the phase of geometric growth. And this in spite of the millions lost through wars, revolutions and counterrevolutions, famines, pestilences, catastrophes, and other calamities of the present half century. In most of the republics of the USSR the reproductive rate is far in excess of that of western Europe. The population of China is said to be growing so fast that all the passenger boats in the world could not transport the increment away if emigration were a possible solution. And Japan produced more than a million and a half babies last year, bringing its population density to the highest maximum yet.

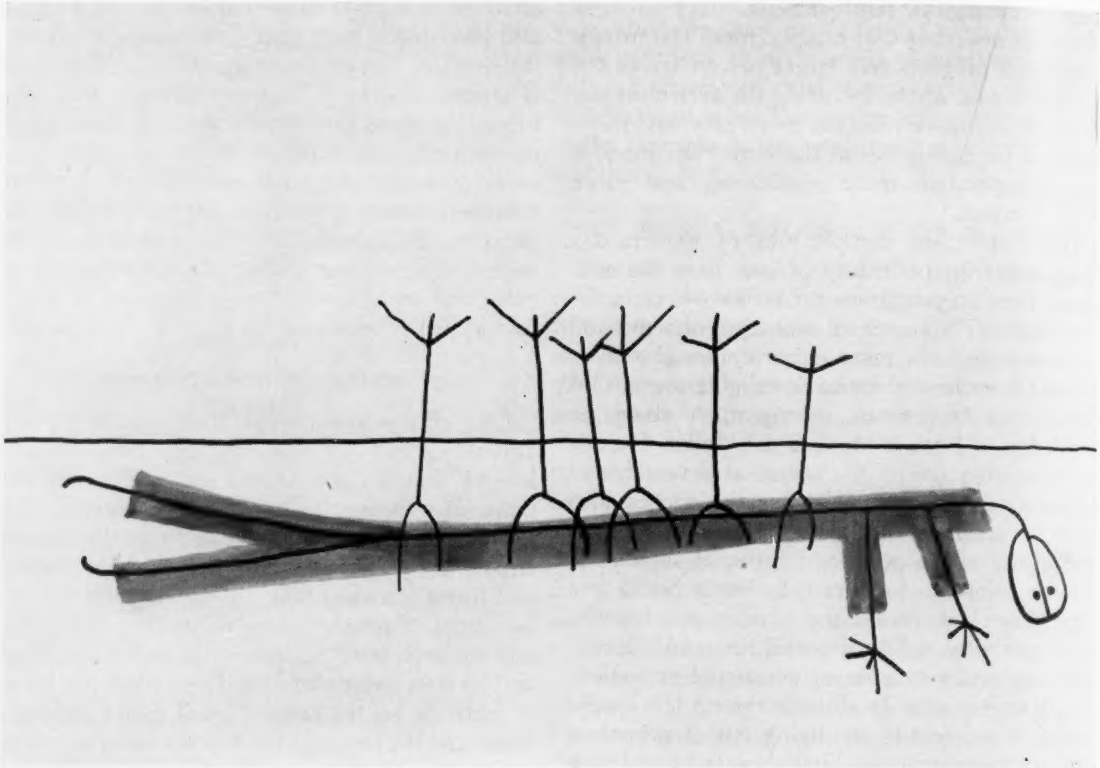
This unprecedented growth of human population cannot be attributed solely to increased technology in the production and distribution of plants and plant products and to the increased acreage of fertile soils brought to the mechanized plow; it has also been due in large part to "mining agriculture," rather than to sustaining agriculture. The result is ironic. The very land-use patterns that have helped increase our population and have raised momentarily the level of living of many of us carry with them the seeds of immediate deterioration and ultimate destruction, for there is a growing pressure of our increased population and a growing pressure of our industrialized philosophy for more and more production, irrespective of loss of balance between productive resources and demand.

THE RESULTS OF OUR HEEDLESSNESS

Our crimes against the land include types of agriculture that result in a steady deterioration and loss of topsoil, such as the growing of one cash crop, like cotton, to the very doorsteps. They include range practices that are inimical to a maintenance of cover, especially in semiarid regions, and forest practices that not only harvest the crop but often, through failure of forest reproduction and subsequent fires, destroy the forest completely and its soils and its wildlife. Even when one knows of methods for the restoration of useful vegetative cover and the repair of the soil, the necessary treat-



Our crimes against the land include . . . the growing of one cash crop, like cotton, to the very doorsteps.



We may be certain that a balance of nature will be attained; but we cannot be certain that this balance will be one pleasing to man.

ment may be uneconomical and impossible under present sociopolitical ideologies.

Accompanying the changes already described, which have brought much of the world's agricultural land to a low state, are a series of consequent water problems. One thinks of the devastating floods that result from inadequate watershed cover, the high sediment burden of streams and their pollution, the lowering of water tables, the drying up of wells, springs, ponds, and lakes, and the loss of irrigation waters. All these changes on the land and in the waters of the land have their effect on wildlife, on food and game fish and animals, on prey and predators, on plant and animal diseases and pestilence—in brief, on the balance of nature. One element of nature, man, has disrupted and dearranged the ecosystem. He cannot prevent the inexorable operation of natural processes, however, and in one way or another he must pay the penalty for his contrariness in a less satisfactory way of life, or even its loss.

We may be certain that a balance of nature will be attained; but we cannot be certain that this balance will be one pleasing to man. Without conservation of our present resources, without strenuous efforts to renew our deteriorated cyclic resources, without both positive and negative checks on the population size, mankind can only wage a losing battle with nature through a series of strategic retreats.

One of the results of a lack of conservation that seems to me to be as inevitable as soil erosion and an ultimately lowered level of living is the development of "human erosion" and of far-reaching changes in our sociopolitical structure. With the loss of the fertile topsoil there is a development of various deficiency diseases, of "hidden hunger," and ultimately such social phenomena as tax delinquency, unfavorable types of tenancy, the maladies of the sharecropper and the "Oakie," resettlement on submarginal lands, and the concomitant deterioration of good human stock along with good soil.

When the relationships between man and the soil are poorly integrated and disharmonious, the average level of living must drop. But averages

alone can give only a partial picture. Under an exploitative economic culture the range of levels of living is very great—the poor are very poor and the rich very rich. Historically, in war and famine, for example, a small minority of exploiters have always done quite well for themselves. And in the cold war of man against nature the exploiters of the natural resources will continue to profit, even as the level of living goes down, not only for the sharecropper and the Oakie, but for the average man, and the disparity will grow between the conditions for him and those for the gougers and pushers.

THE FAVORABLE FACTORS

There are some undeniably favorable factors in this otherwise dark picture. Agricultural production is being increased on a per acre basis by the spread among farmers, in a few countries, at least, of sound practices that permit the use of the land for plant production without its progressive deterioration, and often with striking improvement after a few years. Per acre production is also increased as a result of a variety of scientific investigations, many of which were initiated originally without thought of their possible practical applications.

Some of the most effective discoveries have resulted from increased knowledge of the nature of inheritance and the mechanism of adaptation and evolution. The new science of genecology is resulting not only in selection of ecotypes better adapted for particular natural areas and cultural patterns, but is also actually tailoring new varieties to the needs of certain situations, as in the work of Clausen, Keck, and Hiesey, with the cooperation of the Soil Conservation Service, in the production of new kinds of bluegrass for Western pastures and ranges.

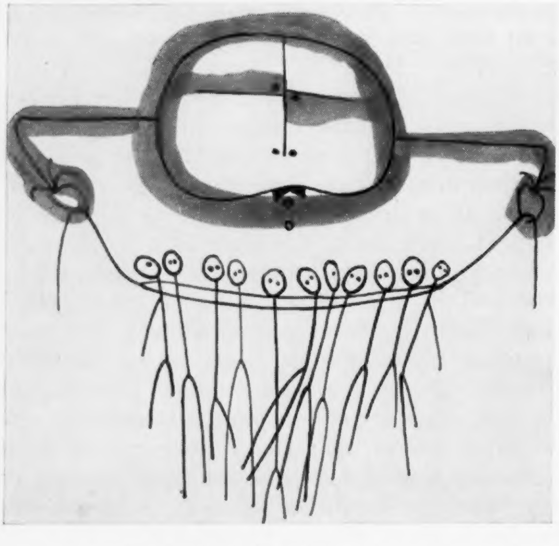
The most dramatic story in this connection is that of hybrid corn. Careful estimates show that hybrid-corn yields are more than 25 percent in excess of open-pollinated corn yields. How much this means was made clear by Dr. Stadler, of the University of Missouri, testifying on the subject of science legislation before the Committee on Military Affairs of the United States Senate. He said:

> A conservative estimate of the increase in national corn production during the four years 1942–1945, due to the partial use of hybrid corn is 1,800,000,000 bushels. The money value of this increase on the basis of farm prices per bushel is more than $2,000,000,000.
>
> It is, therefore, no exaggeration to say, speaking in terms of the overall national economy, that the dividend on our research investment in hybrid corn, during the war years alone, was enough to pay the money cost of the development of the atomic bomb.

Although science and technology offer further enrichments, we cannot expect a solution of food problems or of the wider conservation problems by their means alone. Hydroponics (the raising of plants in soilless water) can be useful only in limited connections. We have also heard much recently of food supplies from marine algae, plankton, and the new fisheries, and these are possibilities worth exploring and developing, but they promise only to be supplements and not solutions. Finally, through genetic and refined physiological studies of photosynthesis, especially with the new research tool of radioactive isotopes, there is an increased hope for an ultimate understanding of the basic food-producing processes associated with photosynthesis. Whether these studies will eventually result in test-tube, pilot-plant, and commercial production of sugar from carbon dioxide and water is a secret of the future.

All technological developments that turn present waste materials into useful plant by-products, and all substitutions for present plant products of less critical materials, aid in relieving the pressure on the land and are conducive to conservation. Also, a change in sources may make for a more economical use of the land. For example, food fats are raised more economically and abundantly per acre from soybeans, peanuts, or corn than from

One of the results of a lack of conservation is human erosion, the deterioration of good human stock along with good soil.



. . . a small minority of exploiters have always done quite well for themselves.

animal sources, as in the case of butter. And the students of microscopic water plants are now promising us a butter substitute from the pastures of the ocean.

One of the most important recent trends toward the solution of resource problems, however, is not in science and technology, but in special education. The idea of the County Agent was a fruitful one, because his job brought him into contact with the farm problems, not as artificially isolated problems but as parts of a complex involving whole agroecosystems. The establishment of the Soil Conservation Service was an even more important step. In this Service, for the first time, the manifold problems of conservation were seen as a whole, and attack was made on them, not piecemeal, but simultaneously, by engineers, soil specialists, agronomists, biologists, economists, sociologists, lawyers, and so on. The Soil Conservation Service introduced the Conservation Districts in 1935, and later the idea of demonstration farms began to take hold. These developments constitute a milestone. They are a great achievement of the mind. Problems are seen whole; solutions are attempted *in toto*. But even more important is the democratic principle of cooperative attack. Through his own effort the individual farmer becomes part of a larger cooperative whole for attack on problems he cannot solve alone. Individualism, independence, and dispersive tendencies—which have been so inimical to conservation in the past—are being replaced by joint attacks, pooling of resources, self-help, and mutual help. Governmental agencies play an important assisting role, but the individual is not collectivized in the Eastern sense behind an Iron Curtain.

The picture is also brighter for conservation in certain developments for the education of the whole public. The work in the United States of the universities and of government agencies, of sportsmen's clubs, scientific societies, garden clubs, the League of Women Voters, the Wilderness Society, parent-teacher organizations, etc. has not been as effective as their energy and earnestness should warrant. This is partly because they have sought to persuade political leaders to favor or oppose legislation instead of educating the voter first and putting their democratic faith in his good offices when he understands the problem. Important in this connection is good writing that captures the imagination—a trick the scientist can seldom turn. Paul Sears' *Deserts on the March* must have been a great help in the government's development of the Soil Conservation Service. Two very recent books promise to play an exceedingly important role in educating and capturing the imagination of the public. I refer to Fairfield Osborn's *Our Plundered Planet* and to William Vogt's *Road to Survival*. Out of Osborn's best seller and an idea of the New York Zoological Society is developing the Conservation Foundation, which is already becoming an important educational agency.

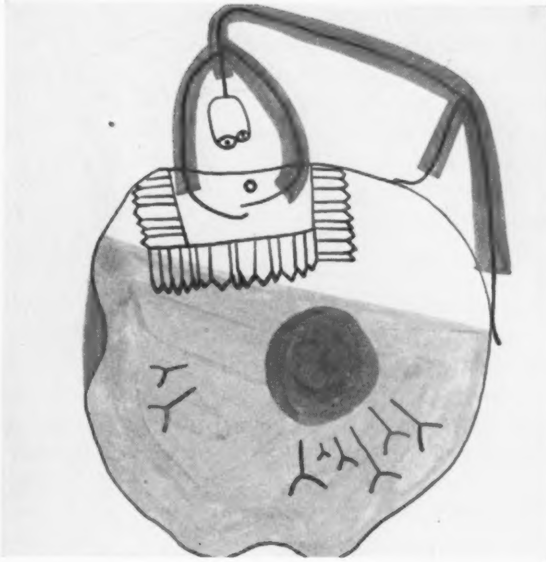
As was said earlier, the problem of conservation is ultimately an international one, and the potentiality of world education in this regard under the United Nations is a large if not immediately hopeful one.

THE FINAL DILEMMA

Summoning to mind every advance toward conservation of natural resources that we can, we still must admit that the favorable factors are on relatively small fronts of battle and that the obstacles remaining are so all-embracing as to require a united attack, which depends on comprehensive governmental action and comprehensive education of such magnitude that, when viewed as a world task, it seems highly unlikely of accomplishment. Actually it is a global problem, this balance between population and resources, and neither of the world's granaries—the American one nor the Eurasian one—can long solve the problem alone. The pioneer conditions of our own geographically expanding nation, the abundance and richness of

our natural resources, the expansion of technology, and the development of our patterns of business and industry have all been conducive to policies of exploitation rather than conservation. Our common psychology has been that of expediency and waste, rather than husbandry and frugality. Our mores, and consequently our laws, have favored the exploitative activities of vested interests, allowing them to batten on the natural resources that rightfully belong to the people, as has been pointed out by Bernard DeVoto in discussing Western grazing interests. Even when large sections of the public and government have felt that something has been wrong with such a process, we have rationalized away our worries with the assumptions that the country is being developed, jobs are being made, the country is becoming rich and powerful —and anyway the future will take care of itself.

In the end, large governmental planning is needed, in agriculture as in industry. Planning is inherent in industry despite stout claims of rugged individualism and cries against regulation and the bogies of socialism. And planning is as natural to modern land use as it is to other types of industry. Industrial planning is for controlled production, controlled prices, profits, and power. Enlightened industry endeavors to keep these tendencies in check so as to keep consumer markets open and the dollar circuit closed. However, society has nevertheless found it necessary to attempt to institute governmental regulation of industry, and in extreme cases, society takes to itself the functions of planning as well as of partial regulation, for it has not been the nature of industrial economy in general to practice conservation of either natural or social resources. But we cannot institute or maintain such governmental steps in a democracy without the positive concerted action of the people.



It is difficult for a specialist to see a problem whole.

Production is also increased as a result of a variety of investigations, many of which were initiated originally without thought of their possible practical application.

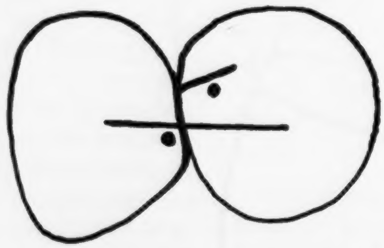
The public apathy, even concerning conservation measures alone, is a reflection of the failure of our educative processes. We have gradually in this country accumulated through the last half century a considerable fund of facts concerning the status of our natural resources. With increasing speed our scientists are learning more and more about plants and vegetation and, more specifically, how we can conduct our agriculture, forestry, grazing, and wildlife management on a sustaining basis. We are discovering the interrelatedness of the elements of the ecosystems, and the futility of attempting to solve human-welfare problems piecemeal. It is becoming clear, for example, that flood control is not just an engineering problem on the lower reaches of the large rivers, but that it involves land-use patterns on the whole watershed; that predator control on range lands is not simply a matter of poisoning or shooting, but is intimately related to overgrazing; that erosion control cannot be ac-

complished by checkdams, or kudzu, or even by individual enlightened farmers alone; and that the fish and game problem is not soluble on a basis of pool- and pen-reared animals. These and all the other conservation problems are too broad for local solution and too complicated for private initiative. They are basically public problems, as are interstate and foreign commerce, war, and the control of atomic energy. Here is where the educatory machinery in conservation has largely failed the general public; and this in spite of the fact that business, industry, and the professions have "sold" the public on technical education.

The failure of general education to date has been the failure to see our problems whole—to see engineering in relation to natural science, natural science in relation to social science, individual problems in relation to population problems and both in relation to resources, and so on, from one class level to another, beyond state and national boundaries, from the present decade to the next century. It is inherent in the human division of labor in our compartmentalized, industrialized economy that it is difficult for a specialist to see a problem whole. But it is just this situation that calls for special effort on the part of all educative agencies interested in public welfare to see the problem whole and to develop a public comprehension at least adequate to allow for a wide public following of enlightened leaders. That is, as Toynbee says, to allow the mimesis by the internal proletariat of the creative minority of society.

It must be remembered that the successful education of the people in conservation is dependent to a large degree on their general education in economic and sociopolitical fields, as well as in a comprehension of the more direct problems of natural resources. Such educative processes are slow, even in countries with a high degree of literacy. They seem overwhelmingly complicated in many countries where the rate of natural-resource destruction is high or where, through past maladjustment, destruction is most advanced, and also where perhaps two thirds or more of the people cannot read.

General education is a concomitant of a high level of living. How can general education come to pass where an abuse of the natural resources is keeping men from reaching a level of living where education about that abuse can be effective? This is the most vicious of chain reactions. We are living at a moment of great and what seems justifiable pessimism, and perhaps man is his own worst enemy. But the dual problems of population control, into the abysses of which we have not looked in this essay, and that of our dwindling resources seem to me ones that have even less likelihood of a solution friendly to man than the control of the atomic bomb.



We are living at a moment of great and what seems justifiable pessimism, and perhaps man is his own worst enemy.

OLD MAN OF THE PRIBILOFS

ALBERT M. DAY

Mr. Day, now director of the U. S. Fish and Wildlife Service, has been with the United States government since his service as a field biologist on the Biological Survey in 1918, and is a national leader in predatory animal and rodent control and in wildlife restoration. He is a national director of the Izaak Walton League and a frequent contributor to magazines and forums.

IN THE heart of Bering Sea, some 300 miles off the mainland of Alaska, lie five dots of land called the Pribilof Islands, named after Gerassim Pribilof, a Russian navigator who discovered them in 1786. Mariners speak of these islands as the "Mist Islands," because they are almost continuously enshrouded in a pea-soup fog.

Although rocky, treeless, rain-swept, and windlashed, this desolate group of tiny islands is, nevertheless, an exclusive summer resort that annually accommodates nearly 4 million visitors. These summer residents—the Alaska fur seals—come once a year, with unerring regularity, to the Pribilofs to bear their young and to breed, because this fogbound bit of land is exactly to their liking. They like it so well, in fact, that this is the only place in the world where they have ever been known to set their flippers on land.

From their oceanic wintering grounds, the forerunners of the annual summer migration appear at the islands early in April or May—sometimes as early as March. These are the lordly breeding "bulls," fat and strong from a winter of ease and feasting. They come ashore, sometimes through remnants of the ice along the beach, to fight furiously among themselves for the possession of their favorite places on the "rookeries," or breeding areas. Weighing on an average around 500 pounds, these big animals have been known to top the scales at 700 pounds.

About the first of June the pregnant "cows," or breeding females, begin to appear from the sea and join the family groups, or "harems." Females weigh around 75 pounds and, rarely, attain a weight of 100 pounds. As the newcomers reach shore, each bull seal, or harem master, collects

as many as 40 or more "wives" for his harem. Once a female enters a harem, she cannot depart. Divorces are not permitted among the fur seals. To prevent rivals from kidnapping his mates, the harem master maintains a day-and-night vigil all summer. At this time he is a very dangerous animal and will attack any man or beast that comes near him or his harem.

Within a few days after their arrival, each pregnant female gives birth to one pup, after a gestation period of between eleven and twelve months. Females bear their first pup when three years old, but the males do not mature to the extent that they are able to acquire harems until they are six or seven years old.

At birth the pups are remarkably large in relation to the size of their mothers, averaging about 12 pounds. They are jet black in color, but toward fall they change to the grayish-brown color of the older fur seals. The pup remains on shore for several weeks while the mother makes trips out to sea two or three times a week to seek the fish that will enable her to produce a store of rich milk sufficient to nourish her lusty youngster. Sometimes she has to go 100 miles or more to get small forms of fish life, particularly the squid, which is abundant in these waters.

After these babies are born, and throughout their nursery period, which is also a new mating season, the "Old Man of the Pribilofs" keeps his many mates in his own bailiwick, battles off rivals, sleeps but little, and never eats until the breeding season has ended, subsisting entirely on blubber built up while at sea. During this protracted period of fasting, the bull seals lose greatly in weight and become so thin and emaciated that when the mating season is over they are barely able to make their way across the rock-strewn rookeries to replenish their strength on the rich foods of the sea, which have been almost within a stone's throw of their long and hungry but ever-constant vigil ashore. As his reward for being the head of a large family, however, the "Old Man" escapes with a whole skin, whereas large numbers of the young bachelor seals in the three-year-old class are killed to furnish the basic material for milady's sealskin coat.

From early spring, when the ice floes recede from the shore, until late fall, just before the Arctic ice pack drifts in for the winter, the seal islands are never quiet. The raucous noise made by the roaring and barking of quarrelsome bulls defending their harems from rivals, the bellowing of flirtatious cows seeking to stray from the family circle, and the bleating of newborn pups waiting for food can be heard at sea for miles. Because the Pribilof Islands, in addition to being far off the beaten path of travel, are a special government reservation upon which no person or vessel may land except under stress of weather or by special permission of the Secretary of the Interior, comparatively few persons have ever witnessed this remarkable assemblage of seal life.

When the hectic breeding season finally comes to an end, the summer colony starts to break up as the temperature drops and the violent winds of Bering Sea start their winter wailing. With the season's pups, which have learned to swim, the seals, individually and in small groups, gradually disappear into the depths of the ocean until nature tells them to return. The bleak islands are deserted, and the long migration of the fur seals to warmer winter waters is under way.

Where the seals go on this migration and what they do is now the subject of an intensive investigation by the U. S. Fish and Wildlife Service. Fishery scientists want the answers to such questions as these: What species of marine life do they eat? In what proportion do they consume this food on their migrations? Are they an economic hazard to commercial fishermen? On their migrations do many of the seals travel along the Asiatic coast? To what extent does the killer whale prey upon pup seals when they take to the water?

The answers to these questions are worth considerably more than \$64 to the United States government because the potential value of the Alaska fur seals today is well in excess of \$100,000,000. They comprise about 80 percent of the priceless fur seals of the world—the raw material for soft, sleek, and expensive coats in which smart women the world over have luxuriated ever since sealskin history began in the days of Russia's Catherine the Great.

The fur seals (*Callorhinus alascanus*), which the United States government manages, are not to be confused with the common hair seals, which are widely distributed over the world. The latter do not have the soft underfur that characterizes the Alaska fur seal and makes it so valuable. The seals that frequent San Francisco's Seal Rocks, to the delight of visitors, are for the most part sea lions—so familiar to circus fans—and hair seals.

Alaska fur seals are mammals that live the greater part of their lives in water. Structurally, they have much in common with bears, except that they are adapted to an aquatic life, whereas bears are terrestrial animals. Instead of feet, seals have

flippers, but when they come ashore they can travel at a fairly rapid rate, at least for a short distance. So much do fur seals resemble bears in their general structure that more than two hundred years ago George Steller, the great German naturalist who accompanied Vitus Bering on his voyage of discovery to Alaska in 1741, described them as "sea bears."

These seals belong to a species distinct from any other fur seals. Other species are found on the Commander Islands, off the Siberian Coast, and on Robben Island, in the eastern part of Okhotsk Sea, now under the jurisdiction of Russia. Fur seals of other species are found also on Lobos Island, Uruguay, off the Cape of Good Hope, Africa, and to a very limited extent in other cold parts of the Southern Hemisphere.

Navigator Pribilof discovered the islands named for him only after a prolonged search had been carried on by the Russians to locate the breeding grounds of the fur seals that were so numerous about the passes of the Aleutian Islands. The Pribilof Islands, at the time of their discovery, were uninhabited, and there is no concrete evidence to indicate that any human being had ever visited them previously. They remained under Russian management for eighty-one years, until 1867, when the United States purchased Alaska and acquired the islands as part of the Territory.

The group consists of five islands, of volcanic origin, three of which are small and relatively unimportant in seal history. St. Paul Island, the largest, is about 14 miles in length. Forty miles away, by water, is St. George Island, 12 miles long.

It is probable that before discovery the Pribilof herd may have contained as many as 4 million animals. Records indicate that prior to 1834 about 2 million pelts were taken under Russian auspices, and by that year the herd had become so reduced in numbers that restrictive measures were applied. From 1835 to 1867, about 600,000 pelts were taken at the Pribilof Islands, and in this period of restricted killing the herd increased to probably 3 million.

The number of seals in the herd when Alaska came into the possession of the United States has been variously estimated at from 2 million to 5 million animals. During the seasons of 1868 and 1869, the first two immediately following the purchase of Alaska from Russia, when killing was unrestricted, about 329,000 fur seals were killed by various independents.

For a period of forty years, from May 1, 1870, to May 1, 1910, the right to take fur-seal skins on the Pribilof Islands was leased by the government to private corporations. The annual take of sealskins under the first lease, which ran from 1870 to 1890, was limited to 100,000 skins, and the total for the twenty-year period was 1,977,377. The annual rental and tax brought a total revenue of $6,020,152 to the government for that period.

Under the second lease, however, there was only one year—1896—in which the take amounted to as much as 30,000 skins, and the total obtained by the lessee during the twenty years ending May 1, 1910, was 342,651 skins, with the government receiving a revenue of $3,453,833. In 1910 the leasing system was discontinued, and since that time, under the acts of April 21, 1910, and August 24, 1912, the Alaska fur-seal herd has been administered, first by the Secretary of Commerce and now by the Secretary of the Interior, through the Fish and Wildlife Service.

In August 1948, when the annual census computation was made, the herd numbered 3,837,131 animals. Since 1910, when the government assumed direct control of the fur seals, 1,498,911 sealskins have been taken, worth approximately $40,000,000. Translated into terms of fur-seal coats, which require from six to eight skins apiece, this total has produced around 200,000 coats.

Fur-seal pup, Morjovi Rookery, St. Paul Island.

Early-season fur-seal harem, N. E. Point Rookery, St. Paul Island, Alaska.

Sealing operations as they are conducted today by the Fish and Wildlife Service on the Pribilof Islands are confined exclusively to the killing of surplus immature males, chiefly of the three-year-old class, designated as bachelors. Considering the number of animals available, the size of the skin, and quality of the fur, the three-year-old males yield pelts of maximum value. In the older males the pelts are of little value. The habits of the fur seals while on land result in the young males herding by themselves, and this makes it possible to drive and kill three-year-olds without disturbing the breeding animals. No female or breeding bull is ever killed intentionally.

The best season for harvesting the crop lies between June 15 and July 31, a period of 47 days. This is the time when the three-year class is dominant on the bachelor beaches and the fur is prime. Earlier, the older males are more abundant, and, later, toward August, two-year-olds and nomadic females swarm onto the beaches. In practice the season is often extended as much as a week in either direction to compensate for natural variations in the time of arrival of the young seals.

Adjacent to the breeding rookeries on the Pribilof Islands are places known as the "hauling grounds" where the young immature male seals, or "bachelors," as they are called, come ashore to enjoy a change of scenery and to acquire knowledge of their future homesites against the time when they will be ready to set up housekeeping for themselves. Not all these young fellows are destined to join a family circle, however, and it is well that they are not. Because of their great abundance and belligerent nature when they come to maturity at six years, many tremendous battles would result in the trampling to death of numerous pups if the breeding grounds were overcrowded with adult males.

It is from these hauling grounds that the seals selected for killing are driven inland a short distance. They can be driven almost as easily as a flock of sheep, but because extensive land travel is foreign to their habits of life they can go only a very short distance before they must rest. These driving operations, therefore, must be conducted with extreme care so as not to overheat the animals and thus lessen the value of the pelts.

Rainy or humid weather is preferred for the seal killing, which is done under the immediate direction of the Fish and Wildlife Service by the resident Aleuts, descendants of the people moved there in early days by the Russians for the purpose of utilizing the fur resources of the islands. These Pribilof natives, now numbering about 500, are in effect wards of the government. They are paid a fee of $2.00 for each sealskin taken on St. George Island, where operations are on a comparatively limited scale, and $1.20 for each skin taken on St. Paul Island. Their primary compensation, however, is through the provision by

the government of all necessaries of life, including schools and medical aid.

In the fur seal, polygamy is perhaps more highly developed than in any other mammal. This fact makes it possible to kill the surplus bachelor animals without decreasing the number of young that may be born. Although the average harem contains about 40 cows, there are records of more than 100 cows in a single harem. The natural ratio of breeding males to females is about 1 to 26. Under the existing system, where only the young males are killed, the ratio approaches 1 to 50.

A suitable reserve of three-year-old males is made each year for breeding stock. The number of this age class to be reserved is determined from observations as to the increase in the herd, the number of breeding males available, and the average size of the harem.

After the animals selected are killed, the skins are removed, washed, blubbered, and given a thorough curing in salt for at least ten days. They are then rolled singly with a generous supply of salt on the flesh side, which is turned inward. Boric acid also is used as a germicide in preserving the skins. From 80 to 100 of the skins are packed to the barrel for shipment.

Prior to 1913 the fur-seal skins taken on the Pribilofs were shipped to London for sale in a raw, salted condition. In addition to being the world's chief sealskin market at that time, London was the principal center for the dressing and dyeing of fur-seal skins. Most of the Alaska sealskins were returned to the United States for use after being dressed and dyed in London. Today the government has a contract with the Fouke Fur Company, of St. Louis, for dressing, dyeing, and selling the skins at public auction.

The process of preparing these skins is a most difficult one, because more than 125 distinct manipulations or treatments are involved. This work requires about ninety days. After grading, the skins are washed to remove all surplus grease and dirt. Nature has given the Alaska seal a guard hair to protect the fine silk underfur which insulates the cold and dampness from the skin of the animal. It is this soft silk underfur that, when dyed, produces the lustrous fur of very high wearing qualities. The skins are subjected to considerable dry heat until the guard hair is loosened and can be removed without damage to the fur. After this guard hair is extracted, the pelts are put through a chamois tannage—no chemicals are used, just good quality oils, which give the same fine soft feel to the leather side associated with the finest type of chamois glove.

Then comes the dye process. Contrary to general information, the fur of the Alaska sealskin is naturally curly, very much like a lamb, and it is the dyeing process that straightens the fur and gives to it the silky, lustrous glow. A grounding solution and numerous applications of dyes are brushed into the fur, producing a permanently straightened fur of exquisite texture. After the dyeing operation is completed, the leather is buffed down to the required thickness; the finishing operation cleans the fur, exposing the true beauty of Alaskan sealskin, and produces a leather that has such a high degree of pliability that it can be draped and molded as easily as fine cloth.

These skins are literally as temperamental as opera singers and have to be handled with the greatest care and skill. After they are finished, they are segregated into various grades, sizes, and lots and are sold to the highest bidder on each lot at a public auction, held twice a year in April and October at the Fouke plant in St. Louis. The net proceeds from these sales are turned over to the Treasury of the United States.

Through careful management and scientific study, the United States government has built up this great herd of fur seals to its high of some 3,800,000 animals in 1948 from a low of about 132,000 in 1910, when it assumed direct management of the herd. At that time it was evident that something had to be done immediately to save this great natural asset. The fur-seal herd had been brought perilously close to extinction through pelagic sealing—the indiscriminate killing of seals while they are at sea. The practice began as a commercial enterprise about 1882 and reached its height in 1894, when approximately 61,000 skins were taken at sea by pelagic sealers.

Pelagic sealing was both cruel and economically wasteful. Only about one out of five animals killed was actually recovered by the hunters before the carcasses sank and the skins were lost. This practice was destructive of males and females alike. After the young were born and while they were still on the island nourished by their mother's milk, each mother seal killed at sea meant the loss of another seal, its pup, which was left on the island to starve. The mother seal does not nurse any but her own pup. Unborn pups were lost if the female seals were killed on their way northward to the breeding grounds, since these pups are born shortly after the females land on the islands.

Pelagic sealing in the north Pacific Ocean was not confined to the nationals of any one government, and with the increase in operations at sea

Fur-seal mother and pup, Little Polovina Rookery, St. Paul Island.

it was soon realized that only by an international agreement could the Pribilof Islands herd be conserved. Diplomatic negotiations with regard to the matter extended over a period of years, and it was not until July 7, 1911, that effective international protection was given to this herd. On that date a convention was concluded between the United States, Great Britain, Japan, and Russia which became effective on December 15, 1911. For the first time subsequent to the development of pelagic sealing the way was cleared for effective conservation and use of the Pribilof Islands fur seals. This treaty was scheduled to run for fifteen years, and indefinitely thereafter until modified or abrogated. After fourteen years any of the four countries signing the treaty could give one year's notice of a desire to modify or cancel the agreement.

An outstanding feature of the convention was that it prohibited pelagic sealing in waters of the north Pacific Ocean north of the thirtieth parallel of north latitude and including the Seas of Bering, Kamchatka, Okhotsk, and Japan, except for the limited operations by primitive methods carried on by Indians and other aborigines dwelling on the coasts of the protected waters.

This convention, commonly known as the North Pacific Sealing Convention, also afforded protection to the Japanese fur-seal herd at Robben Island, estimated to contain not more than 50,000 animals, and the Russian herd at the Commander Islands, with probably fewer than 100,000 animals.

In return for the surrender of such profits as their nationals had been deriving from pelagic sealing operations, an allotment of 15 percent of the fur-seal skins taken annually on the Pribilof Islands was made to both Canada and Japan. Russia was a signatory of the treaty only in the interest of the seal herd on her side of the Pacific. Throughout the life of the treaty, Japan took her share in cash, which amounted to more than $1,500,000. Until 1933 Canada took her share in cash, but after that date she often elected to take actual delivery of her share in skins.

Under the terms of the Convention of 1911, and the wise management practices employed by the United States government, the seal herd continued to increase year after year. It was not until 1940, however, that the harmonious relations existing among the signatories were disrupted when Japan served notice on our government that on October 23, 1941, it would abrogate the Convention. Japan alleged that the fur-seal herd, at least in part, migrated down the Asiatic coast and had grown so large that it was devouring valuable food fishes essential to the economy of such a fish-eating nation.

The records and findings in the possession of the United States government at that time, developed by the United States and Canada over

many years, indicated, however, that the migrations of the seals were primarily along the eastern side of the Pacific. Moreover, studies of stomach contents disclosed that the fur seals fed largely on squid, pollock, seal-fish—a small deep-water fish—and other noncommercial species; very few salmon were eaten.

To bring the United States data up to date, the Fish and Wildlife Service began to make plans for an extensive investigation of the migratory and feeding habits of the fur seals, as well as the entire life history of these animals and of their relationship to the fisheries and to other economic interests.

On June 30, 1941, the Seventy-seventh Congress appropriated $290,000 to the Service to start the fur-seal investigation. From these funds the Service purchased the three-masted schooner yacht *Black Douglas* and began work at Savannah, Georgia, to equip it as a floating laboratory for studying the seals and their alleged poaching during their long migrations on the high seas. Before the vessel ever reached Seattle, however, war was declared and a submarine in Pacific waters nearly ended the career of the *Black Douglas* and its crew. By blacking out, and cutting its motor so the submarine could no longer trace that sound, the vessel escaped by using sail. When the *Black Douglas* arrived in Seattle it was requisitioned by the Navy, its scientists and crew disbanded and returned to their homes, and the seal investigation shelved "for the duration."

The matter of protecting the fur seals, however, was not neglected during the war. A provisional agreement for their protection was signed by Canada and the United States in December 1942. On February 26, 1944, the President signed a new fur-seal law to give effect to this provisional agreement. With enforcing legislation by the Canadian government, the agreement provides, among other things, that 20 percent of the skins taken on the Pribilof Islands shall become the property of Canada, the remainder to be retained by the United States. The Act of February 26, 1944, brings together, with only minor changes, all previous legislation directly affecting the Pribilof Islands fur-seal herd.

In May 1947, re-equipped as a floating laboratory, the *Black Douglas* left Seattle, Washington, for the Pribilof Islands to seek new data on where the seals go when they leave the islands, what food they eat, and whether the young seals are preyed upon by other marine mammals.

As part of their work during the summers spent on the islands, Service biologists attached metal tags to the flippers of thousands of seal pups in

Fur-seal pups playing in the surf and learning to swim. Vostochni Rookery, St. Paul Island.

each of the years 1947 and 1948. Recoveries of these tagged seals at sea during the coming years will yield specific information on the migration habits of the seals. In 1950, when the 1947 crop of pups will be ready for killing, a statistical study of the recoveries of marked three-year-olds on the killing grounds will make possible a check on the accuracy of seal census methods now in use.

From observations made to date of tagged seals that return to the islands, the fur-seal experts have already obtained valuable data. For example, we know that as seals mature they tend to return in increasing proportions to the exact area of their birth. We also know that seal cows may produce pups when they are twenty years old. We have been able to get exact figures on the rate of growth of seals, as well as a variety of other facts that are essential in the management of the herd.

Observations on fur seals in captivity have contributed information obtainable in no other way. Such observations have indicated that the daily food requirement of a medium-sized seal is about 10 pounds. The only seals in captivity now are six in the Balboa Park Zoo, in San Diego, California. On August 8, 1948, one of them gave birth to a healthy youngster, the first ever to survive birth in captivity, after a gestation period of at least 374 days.

The degree to which the fur-seal herd may be further developed is another point scientists are seeking to determine. The causes of mortality, also, are not well known, since most of them occur while the seals are at sea. The losses are probably greatest when the young pups, at the age of four months, leave the islands in November and venture into the stormy and treacherous waters of the Pacific. Many of them are thought to be destroyed by killer whales. In the stomachs of two whales stranded on the island, 18 young fur seals were found in one and 24 in the other. Hookworm is also causing the death of an increasing number of newborn seals.

Wringing excess sea water from freshly blubbered skins; action is from right to left.

When these current investigations, which will cover a period of years, are concluded and the results analyzed, the Service expects to have available a wealth of authentic data on the migrations and food habits of the fur seals and their relation to other fishery resources of the north Pacific to use as the basis for its work of protecting and perpetuating these valuable natural resources.

Fortified with new scientific data, the United

Salting fur-seal skins on St. Paul Island.

States government will be in a position to combat any demands for the return of the days of unbridled exploitation of the fur-seal herd. Without the immunity from pelagic sealing which the North Pacific Sealing Convention gave to the fur seals, the herd might be commercially extinct today instead of being an important source of revenue to the government. When the Convention became effective in 1911, the government was enabled to manage the herd in accordance with a scientific program of conservation and utilization. That the herd is nearly thirty times as large today as it was in 1911 is proof of the success of this program. To return, then, to the former destructive practice of pelagic sealing would undo what is regarded as the world's outstanding achievement in the restoration of a great wildlife resource through international cooperation.

AN AMERICAN PASCAL: JONATHAN EDWARDS

RUFUS SUTER

After receiving his Ph.D. from Harvard in 1932, Dr. Suter went to the Library of Congress as cataloguer in philosophy and, later, as a Fellow in the Asiatic Division. He is now with the Army Map Service, Washington, D. C. Dr. Suter has written on Francis Bacon, Blaise Pascal, and Descartes for THE SCIENTIFIC MONTHLY.

AS paradoxical a personality as any to be found in the novels of Dostoievski was Blaise Pascal. A founder of modern experimental physics, he belonged to the distinguished company of Galileo, Torricelli, Gilbert, and Boyle, and as a mathematician he was the peer of Descartes. Yet at the height of his powers he allowed his scientific interests to be smothered by what some of us today would call a pathological obsession with the morbid side of religion.

America also had a Pascal. Although his scientific achievements were not equal to those of the young man from Clermont, he showed in his boyhood signs of an aptitude that might have flowered if a religion as lugubrious as that of his French predecessor had not nipped it in the bud. The resemblance is the more striking since the theology that monopolized the energies of both men was the same. Pascal became the champion of a community, now extinct, within the Church of Rome, known as Janssenism. Its teachings were indistinguishable from those of Protestant Calvinism, because it derived from the same source: a somber convert of the ancient world, Saint Augustine. The American Pascal was the last great defender of the abstract principles behind New England Calvinism, known more familiarly as Puritanism, the religion of the Pilgrim Fathers and the Mathers. This American Pascal, grandfather of Aaron Burr and grandfather-in-law of Eli Whitney, missionary to the American Indians and president of Nassau Hall, was Jonathan Edwards. He was born in 1703 at East Windsor, on the banks of the Connecticut.

Edwards' power as a psychologist and psychoanalyst is comparatively well known. What makes the resemblance between him and Pascal striking is that in his case, as well as in that of the Janssenist, a precocious early insight into the problems of physical science was sacrificed to the religious passion. That Edwards, while still in his teens, wrote eight sheets of foolscap treating brilliantly, among other topics, of physics, meteorology, and astronomy,* is little known. He did not have the genius of Pascal. But his youthful scientific aptitude may be compared favorably with that of many another eminent man, such as Franklin, Kant, or Swedenborg, whose early bent toward science was later eclipsed by other interests. An examination of some of the high lights of these eight sheets of foolscap is worth the attention of any student of the history of American science.

I

The method of inquiry Edwards adopted was after the geometrical model. He uses definitions, axioms, postulates, corollaries, lemmata, etc. He introduces geometrical diagrams. His technique of proof is either straightforward deduction, or a technique he subsequently applied in his theological writing: demonstration that the contradictory of the proposition to be proved is untenable. There is evidence of meticulous observation, but no controlled observation in the sense of laboratory experiment. Many of his ideas are put forward as hypotheses, to be investigated later.

As with some modern fundamentalists, Edwards' astronomy is uninfluenced by the infallibility of Genesis. This is astonishing, since, as the literalistic critics of Galileo (Protestant as well as Catholic) knew, Genesis supports the geocentric view of stellar and planetary motions, by implication if not explicitly. But the opinion of Urban VIII, Luther, Calvin, and Wesley made no impression upon the Yaleman from East Windsor, who shows not the least hesitation to accept the astronomical system of Galileo and Newton. In a paragraph about the frail human tendency to set

* This material was collected and published under the heading "Notes on Natural Science" as part of an appendix to an anonymous biography of Edwards. The biography is Vol. 1 of *The Works of President Edwards: with a Memoir of his Life.* In ten volumes. Vols. 1, 3–6, 9–10, pub. by G. & C. & H. Carvill, New York, 1830; Vols. 2, 7–8, by S. Converse, New York, 1829–30.

up familiar experiences of everyday life as standards of possibility and impossibility, he points out that even among the learned are some who, to ease their imagination, are ready to fall back into the antiquated system of Ptolemy, merely because they cannot conceive how the fixed stars can be so distant "as that the earth's annual revolution should cause no parallax among them."

His knowledge of the remoteness of the fixed stars led him to a proof of the impossibility of their diurnal revolution around the earth. If they are to encircle the earth in twenty-four hours, their speed must be at least ten times the speed of light (in fact, it must be several thousand times). Edwards then illustrates by a diagram that the light emitted from the stars would be tossed off at a tangent to their orbit and would miss the earth. If the Ptolemaic notion were true, nobody on the earth would ever have seen a star.

This knowledge of the vast distance of the fixed stars also convinced the youthful Yaleman that the stars are suns. At their distance they cannot shine by the reflected light of our sun. Old Sol is, conversely, a star.

In view of the preoccupation of many astronomers of the past twenty years with the sidereal system, of which our family of planets and even the galaxy are a small part, another line of astronomical reasoning by Edwards is of interest today. He suggests the possibility that the universe, or "Starry World," is a spheroid. The proof, he believes, would be forthcoming from observation of the Milky Way. We could determine our position within this spheroid by observing how far the galaxy departs from being a great circle. This would give us our vertical distance from the galactic plane. We could, then, observe the ratio of brilliance of opposite sides of the Milky Way. This, compounded with several other ratios, would give us our horizontal distance from the center of the plane we occupy.

Outside this spheroid, the matter must be evenly placed in order that the gravitational pull should not upset the nice adjustments within the system. The necessity for this uniform distribution might be avoided if the spheroid rotated; but we must outlaw this rotation, because it also would cause disturbances in the perfectly symmetrical and regular motions of the planets, comets, and other journeying, whirling masses of matter within the spheroid.

Edwards' cosmological ideas, thus far, are in tune with the modern note. We know that our local sidereal system is lens- or watch-shaped, and not a spheroid. But the difference is not too great; and the determinations have been made, as Edwards foresaw, by study of the Milky Way. We have our so-called Island Universes, such as the Nebula of Andromeda, which are matter outside the spheroid of our universe, although they are not evenly distributed. In view of this modernity it is by surprise that we finally catch a weird echo from the medieval concert. Our future Calvinistic theologian wonders whether there may not be an enclosure to the spheroid, and whether this shell, if it were absolutely solid, could not withstand violent shocks by gigantic bodies—as if Lucifer might declare war on the universe.

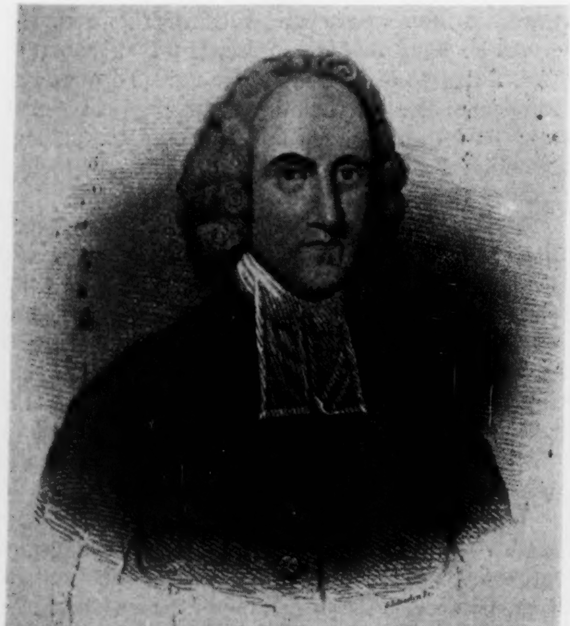
The idea of a spheroid of the Starry World suggests the image that the sidereal system may be a particle—a drop of water, say—in a universe at a higher level of magnitude; or that a particle on a blade of grass may be a sidereal system at a lower level of magnitude. This fancy Edwards unceremoniously rejected. The same speculation fascinated Pascal, who saw an infinite series of telescoping universes. The reason for Edwards' objection is not clear, but we surmise that his general stubborn resistance to read infinity into the size of the physical world was at the bottom of it. Infinity in the mathematical sense of approach toward a limit was beyond Edwards' horizon. He seems to have thought of infinity as a concrete fact, a degree of being actually real. To attribute infinity to the dimensions of the physical world may have appeared to him a kind of blasphemy, although he had no sensitiveness about seeing infinite forces acting in the physical world.

The young man at Yale had several other astronomical insights. The precession of the equinoxes he understood to be the effect of a gyration of the earth's poles. He sets the period of this gyration at 25,200 years, instead of at 25,800 years, which is the period stated in modern texts. He had some inkling of the physical condition, vast size, and terrific temperature of the sun, and he shared in the eighteenth-century literary fancy that the moon is inhabited.

We shall find that Edwards' meteorological insights are often on the right track. The grand problem: Why is winter colder than summer? he met with four solutions, three of them clarified by geometrical diagrams. The principle is that the relative nearness of the sun to the horizon in the winter, hence the obliqueness of its rays, accounts for the winter coolness. The sun's high altitude, on the other hand, in the summer, hence its chance to hit the ground with perpendicular beams, explains the summer heat. Two of the solutions are ingenious enough to be looked at in detail. The

first of them presupposes the theory that heat is a violent agitation of atmospheric particles. In the summer, when the perpendicular rays of the sun strike the earth's surface, the reflex rays retrace, more or less, the lines of their incidence, in accordance with a well-known law of optics. With this much beating back and forth along the same road, the atmospheric particles joggle each other into a fury. Temperature, in other words, is high. In the winter, with the sun shining low on the horizon all day long, the situation is different. The oblique rays, even if they struck a smooth surface, would be reflected at an obtuse angle, so that most of the reinforcement of the struggling atmospheric particles would be lost. As facts are, the surface of *terra firma* is rough, and reflex rays are struck off indiscriminately at every which angle. Summer's reinforcements are lacking; the particles beat each other into only a relatively thin, lethargic turmoil. Winter temperatures, consequently, are low.

Edwards' other ingenious explanation is one to be found in modern textbooks. A sheaf of parallel rays striking a surface oblique to them touches it at points further apart—hence over a larger area—



than the same sheaf of rays would if impinging upon a surface perpendicular to them. This is a simple fact of projection. To express the same phenomenon otherwise: Struck horizontally, a unit area on the earth's surface receives fewer rays than when struck perpendicularly; hence winter is colder than summer.

Another happy meteorological thought of Edwards has to do with why thunder starts with a clap near at hand, then rumbling and muttering seems to roll away into the more distant reaches of the sky. The lightning, on the other hand, is over in a flash. Edwards' analysis of this phenomenon is as neat as any to be found among the recorded boyhood cogitations of Pascal. The lightning, to be sure, is over in a flash; but the flash extends through a space, one end of which is likely to be further from us than the other. Sound travels more slowly than light. It is thus to be expected that while out there, where the lightning happens, the thunder is over as quickly as the flash, the sound reaches us successively, in accordance with the difference in distance from us of the various points along the flash. Inevitably, in fact, we occasionally hear thunder backwards. If the start of the flash is further out in the sky than the end, the thunderclap which accompanies the violent climax of the flash may take less time to reach us than the noise of any of the antecedent parts of the flash; so that the pandemonium seems to be in reverse order to the actual events: the clap apparently sounds first, and the din of Rip van Winkle's rolling pins seems to recede subsequently into the distance.

Edwards explained lightning as an almost infinitely fine combustible matter, floating in the air, that becomes incandescent by a "sudden and mighty fermentation." Once aglow, this "fluid matter" divides the air as it darts, each moment receiving new impulses by its continued fermentation. The zigzagging directions of its flight are determined by the differences in atmospheric temperature. Its particles are "so fine, and are so vehemently urged on, that they instantaneously make their way into the pores of earthly bodies, still burning with a prodigious heat, and so instantly rarifying the rarifiable parts."

Our Yale pupil here is struggling to express the identity of lightning and electricity a generation before Franklin's kite experiment. It is interesting to note that the continued usage today of such terms as current, direction of flow, resistance, etc. is a throwback to the days when electricity was generally considered a "fluid matter."

Edwards understood correctly the nature of

clouds and rain. He recognized that the twinkling of the stars is an atmospheric phenomenon, and he explained the fact that the stars twinkle though the planets do not as a result of the comparative slimness of the parcel of rays from bodies so distant that they are points of light. The least disturbance in the earth's atmosphere is bound to interrupt what would otherwise be as steady a glow as that of Venus. Edwards, however, was confused in his understanding of the atmosphere. He appreciated that it is, in part, composed of vaporous exhalations from the earth (tiny bubbles) drawn up by the sun and, perhaps, by the force of attraction of the clouds, but he thought that an important part of it is also the particles of the ether, packed more thickly near the surface of the terrestrial globe (or of any planetary globe) than in empty space, because of the power of attraction.

In our survey of Edwards' astronomy and meteorology we have already mentioned, in passing, several of his inspirations in general physics. He knew that light travels at a finite speed. He evidently had adopted Newton's corpuscular theory of light. He also knew that sound travels, and vastly more slowly than light. He recognized that sound is a vibration in the air. He knew that heat is a violent agitation of particles. He was deeply impressed by Newton's law of gravitation. He alludes once (a point we have not mentioned) to Newton's third law of motion, that every action has an equal and opposite reaction. He understood (another point we have not mentioned) that air has weight, and that bags from which the air has been sucked do not collapse because of any horror of the void, but because the weight of the surrounding air pushes them in. He was probably convinced of the doctrine of the conservation of matter.

II

Edwards is most exciting, however, as a theoretical physcist. His discussion of the atom is a fascinating bit of scientific curiosa.

The conventional picture of the atom as the particle having the quality of *least reducibility* (a purely mathematical attribute) he rejects and substitutes in its stead an entity having the quality of what he calls *indiscerptibility* (a mechanical attribute). An atom, that is to say, is a thing that cannot be fractured by the existence of any finite force. Or, to put the distinction in another way: Conventionally, when a person says that an atom is a body so small that it cannot be divided, he means by "cannot" the inability in a geometrical sense to halve any further. The last term in a series of halvings has been reached; space proves to be geometrically incapable of further division. The difficulty with this notion, of course, is that extension may be infinitely divisible, in which case there could be no atoms. For Edwards, however, "cannot" means "not enough strength" to halve any further. Any finite force of pressure, torsion, collision, attraction, or whatnot would be too weak to break the atom. The question of whether space is or is not infinitely divisible is irrelevant to the problem of the existence of the atom. An atom may be as large as the universe. On the other hand, millions upon millions of submicroscopic atoms doubtless exist. Size has no bearing upon their nature.

Edwards goes into detail in the analysis of indiscerptibility. An indiscerptible body is a *plenum*. That is, it is absolutely full and perfectly solid. This does not mean, however, that an atom may not be honeycombed with pores—or even that there may not be more empty than filled space in it. A thing is *plenum* when every part within it is in "contact by surface" with some other part, all of which parts may run up and downways and criss-cross between the pores.

The term "contact by surface" is significant. Edwards emphasizes a distinction between "contact by surface," which is true physical contiguity, and "contact by point or line," which is an abstract, ideal, mathematical contact to be found in the conceptual world of textbooks on geometry. Countless millions of points or lines of contact would not generate a single contact by surface. But whenever surface contiguity happens in nature, the touching bodies become indiscerptible, become one *plenum*, parts of one self-identical atom.

We might suppose that eventually an inconveniently large number of bodies would touch by surface, so that the universe would gradually coagulate. Probability makes this unlikely. The chances are only one in many millions that any two atoms would have such shapes that any part of the surface of one could perfectly dovetail into the surface of another; or that, if so, these fortunate ones should happen to meet; or, if they should happen to meet, that the proper faces should be turned toward each other. We may assume, however, that such unions do happen in immense numbers at submicroscopic levels.

Edwards betrays the sound scientific instinct to generalize, by trying to identify gravity with the indiscerptibility aspect, or the aspect of perfect solidity, of the atom. One step in this process is almost bizarre, though its precocious ingenuity cannot be denied. The indiscerptibility of the atom, he

attempts to show, is the cumulation of an infinitely large quantity of gravitational force, generated by the mutual pulls of the infinitude of material parts within the atom. The proof is an application of Newton's law of gravitation, F equals Mm/d^2, to a geometrical representation of an atom. The infinitesimal qualities of F are supposed to add up to an infinite quantity of F, or cohesive force holding the atom intact.

The concept of the indiscerptibility of the atom is an interesting logical toy to play with; but if Edwards were alive today the recent splitting of the atom would force him to revise his views.

The last step of Edwards' theoretical physics is a transition to metaphysics—a dénouement occasional among modern physicists. He concludes that matter is solidity. If some thinkers have conjectured that matter is extension (he may have Descartes in mind), the rebuttal is: Extension of what? Obviously, extension of solidity. By making the appropriate substitutions we may reach the strictly equivalent proposition that body *is* gravity. Newton thus has the first say in metaphysics as well as the last say in physics.

There is an analogy between the European students of Plato and the older school of Edwards' scholars. The former have commonly shown an antipathy toward regarding Plato, or any of the other Greeks, as indebted to any culture prior to ours outside of Hellas—to India, for example. Similarly, there has been a tendency to regard Edwards as either wholly original in his nontheological thought, or at most as deriving it from a purely New England background. Much has been written to prove that his boyhood metaphysical idealism was not suggested by Berkeley, but sprang full-blown from his own mind. It is, indeed, difficult to reach any certain conclusion about how much of Edwards' scientific and philosophical speculation was original. In the very foolscap we have been reviewing he states as an ethical rule never to appear to be widely read by alluding to learned authors. It is a paradox that this rule, intended as a discipline against boasting, may have had the effect of causing Edwards to appear to later generations as more of a genius than he was. We know at least that he was familiar with Locke's *Essay*. In the eight sheets of foolscap the only authors he names are Newton and the materialist Hobbes, whom he dismisses.

Whether Edwards' scientific opinions were mostly suggested by reading of European authors or not, it should impress the student of the history of American science that within little more than a century since the death of Gilbert, and within less than a generation since the death of Boyle, the essentially modern scientific world view should have seeped down to a boy in a college in a remote colonial town.

The world no doubt lost in Edwards a philosopher and possibly a great scientist. The tragedy in his case is more complete than in Pascal's for whereas the religious community to which the Janssenist sacrificed his science has become defunct, Pascal's tract, the *Pensées* still has something to offer the devout soul. But the harrowing theology of Edwards, which swallowed up both his natural philosophy and his science, is dead even in the Congregational churches that nurtured him and the other Puritans.

ANTHROPOLOGY: A BRIEF SURVEY

ROBERT W. EHRICH

Dr. Ehrich, of the Department of Sociology and Anthropology, Brooklyn College, first prepared this article to inform European colleagues of trends and developments in American anthropology since 1939, when the international exchange of information was interrupted. In its original form it appeared in the Polish annual Lud, *1948, XXXVII. In a somewhat revised form, it is presented here for an American audience.*

THIS article is an attempt to synthesize some of the trends and developments in the field of anthropology during the past ten years. Intense activity in the various specialties has added much new material, contributed many new concepts, and drastically revised many older ones. Limitations of space preclude a detailed treatment of any one subject, and only those aspects that seem of outstanding importance will be mentioned. Even so the list is far from complete. The discussion and bibliography have for the most part been limited to American work, but some studies not of American origin are included. This is particularly true of some phases of archaeology and physical anthropology.

The term anthropology is here employed in its broadest sense and includes physical anthropology, ethnology, ethnography, social anthropology, and archaeology, as is customary in British and American usage. In this paper the divisions into cultural anthropology, archaeology, and physical anthropology only are made.

Although not often stated, and sometimes explicitly denied, there is implicit in much of the modern work the assumption that the dynamic processes and laws attributed to man's institutions cannot be divorced from those pertaining to man himself. The highest common denominator in the analysis of culture is man, and the present tendency is to examine the cultures of living groups in terms of people. Although there are marked schisms in the various schools of thought, it is increasingly obvious that the preoccupation of many social anthropologists with the psychological approach is a recognition of this principle. The consideration of physiological, biological, and constitutional factors must follow as a matter of course.

The concept of man and his works must therefore be regarded in the nature of a continuum, and consequently culture cannot be analyzed in terms of abstractions and laws apart from the human animal. In order to attain predictability, the anthropologist must not only strive to obtain a cross-sectional view of modern man and his ways of life, but he must also find out what has happened to man in the past, how he has developed, how he has reacted to various stimuli, and what he has produced. In these terms, recourse to known history and to archaeology is vital, for we must obtain the case history of man if we are to understand him at present and throw light on his future.

The three major topics to be discussed are interrelated in terms of this broader view, and the specific approaches and schools of thought mentioned illuminate various facets of the larger objective. The specialist will find some of the interpretations open to challenge, ample grounds for disagreement with the writer's assessments, and various omissions and disputable classifications in the bibliography. This paper, however, represents an effort to provide the nonspecialist with a brief orientation in the type of thinking and research now current.

CULTURAL ANTHROPOLOGY[1]

In recent years there has been a marked tendency toward the breaking down of formal barriers between the various social sciences. This has been carried to such an extent that it is almost impossible to define the limits where sociology and social psychology stop and social anthropology begins. Indicative of this trend has been the establishment of the Institute of Human Relations at Yale University and the Department of Social Relations at Harvard University, in both of which social scientists from several fields collaborate. At the present time there is a great deal of collaboration, cooperation, and coordination among specialists. Not only have anthropologists been called to participate in the solution of problems in such fields as mental health, family life, child care and development, and hygiene, as well as those

of administration and group relations, but volumes incorporating the various aspects of the social sciences are also appearing.[2]

In research of both ethnographic and cross-cultural ethnologic character, emphasis shifted some time ago from the purely descriptive approach to a concern for isolating the fundamental and dynamic processes that shape both the individual and his culture. The most recent trends in cultural anthropology fall into two main areas, which can be further subdivided. The first concerns itself with the determination of cultural forms and with the techniques for analyzing the dynamic implications of their components. The second deals with the problem of the individual in culture, particularly with the influence of culture upon the personality of the individual. Although conceptually distinct, these two fields of interest are by no means mutually exclusive, and both approaches are usually incorporated within single studies.[3]

The present tendency in American cultural anthropology is not so much to eschew theoretical approaches as it is to avoid the overschematized positions of the more extreme schools. Both in theory and in operational method the trend has been toward an eclecticism and synthesis of the several approaches that are selected and applied to the problem in hand.

One of the chief efforts of those representing the so-called structuralist school lies in describing cultures *in toto* and in determining the forms of their analyzable components relative to group value attitudes. Their basic position is closely akin to that of the gestalt psychologists in that they recognize in specific cultures individual flavors somewhat different from the sum of the recognizable parts. Like the personality of the individual, this ethos seems, in part at least, to stem from the projective systems and personality-forming traits within the culture of the group. A variant approach is Opler's view that the value system of a society is organized around several themes which are not necessarily harmonious or consonant with one another.

Basic concepts of this school are expressed in the use of terms such as ethos, configuration, pattern, and theme, but the struggle for clarity continues. The data are clear enough, as are the interpretations of individuals working in this field, but the semantics of this approach are not yet established. Kluckhohn (in Spier, bibliographical note 2) has suggested that the term "pattern" be used to denote structural regularity in overt culture, and that a sharp distinction be made between ideal and actual behavior patterns. He would restrict the term configuration to express structural regularity in covert culture. There is, however, no uniformity as yet in the exact definition of these labels, nor is there standard practice as to the levels of abstraction for which they are used.

Essentially the treatment of culture in terms of structural analysis resolves itself into a study of group values and group expressions of behavior. In order to assess a cultural structure from this viewpoint, historic, functional, and personality analyses must be fused. Implicit in this approach is its direct applicability to specific problems, such as the processes and effects of acculturation among specific groups, adjustment problems resulting from the retention of cultural heritage by minorities, and the relation of the individual to his social and cultural environment. In this regard interest is centering on the cultural patterning of larger groups such as nation and tribe and also on that of smaller divisions such as communities[4] and minorities of specific national origins.

The study of personality formation, on the other hand, is the analysis of group norms in behavior, psychology, and the like within the structural framework and the recognition of deviants and their place within a given culture. This approach involves the isolation of basic personality as well as the classification of personality types within a community or cultural group and the recognition and classification or labeling of the conditioning factors. Techniques employed include the structural and functional analyses of the specific cultural background; concentration upon the periods of infancy and childhood in regard to treatment, and attitudes and relationships between adults and children, between children, and between adults; and the use of projective techniques such as the analysis of childplay, games, and the use of Porteus, Rorschach, Thematic Apperception, and other tests. Many of the recent group studies combine these approaches. Conversely, but in the same vein, Kardiner[5] is attempting to apply psychiatric interpretation to projective systems within cultural data and to define the reciprocal relationships between culture and personality.

Although several works long antedate the period under discussion, native autobiographies and accounts and semifiction which competently fuses ethnographic data into consistent, patterned life histories as seen through primitive eyes are other means employed by these schools.[6] These devices bring into sharp focus the character of a given culture, the value attitudes of the people, and, by implication at least, the projective systems, the basic personality norms and deviants, and the proc-

esses and degrees of acculturation of the individuals and of the group.

On a practical level this school is throwing a great deal of light on problems of acculturation, cultural change, administration, and on industrial and class relations. They are also testing many generalizations on human behavior which were propounded in the past from viewing our own culture alone.

A somewhat different approach to similar objectives appears in the work of G. P. Murdock's cross-cultural survey, conducted by the Institute of Human Relations at Yale.[7] The object of this study is to build up as complete an ethnographic picture as possible of a large number of diverse cultures and then to test generalizations of presumed association and correlation by statistical analysis of the recorded phenomena.

Another method of culture analysis is based on the definition of cultural anthropology as the science of human relations. In an attempt to reduce such a study to an objective technique, Chapple and Coon[8] offer an analytic tool of research in the objective definition and quantitative measurement of interaction between individuals and among groups. Patterns of relationship thus established throw light on the functional significance of institutions, on the forms of specific institutions in response to their contexts, and on the processes of culture continuity, diffusion, and change.

For new material of the strictly functional school, attention should be called to two posthumous publications by Malinowski. *A Scientific Theory of Culture*[9] presents a clear formulation and dissection of his theoretical approach, and *The Dynamics of Culture Change,* based largely upon African material, tests the applicability of his concepts to administrative problems. Although not strictly comparable in approach, other acculturation studies express the same concern and inquire into the causes, dynamics, and forms of culture change and explore the problems in human relations and cultural disintegration that arise from it.[10]

As a modified survival of the older evolutionistic approach the neoevolutionist school of thought should be mentioned. Headed by L. A. White,[11] this group is still struggling with an over-all theoretical formulation and explanation of culture and its growth. They base their approach on per capita consumption of energy.

Although less sharply defined as a clear-cut anthropological attack, the work of one other group should be mentioned. This is the so-called sociological school,[12] which concerns itself with the analyses of communities within our own civilization. In theory and in operational technique, however, its approaches are largely ethnographic and ethnologic in that it combines the same considerations of material culture, functional institutions, structural configurations, group values, and personality formation that characterize modern studies of primitive and nonliterate cultures. Much of this work to date is primarily concerned with class and caste, but other themes are also analyzed or are implicit in the group's general treatment.

In America the present trends of cultural anthropology indicate that the field, in spite of its lack of distinct boundaries, is coming of age. Although there is still much to be done in the formulation and elucidation of theory and methodology, much that has been learned in the laboratory of the simpler cultures is now being applied directly to the understanding of problems within our own civilization. On the evidence afforded by the universality of culture borrowing, configurations, personality structures, and the like, the psychic unity of man is generally accepted, and this premise is implicit in practically all work being carried on today. When we add to this the concept of a culture as a system of learned designs for living, the study of culture becomes an analysis of individual and group reactions to forces which cause development and change and to forces which limit the possibilities of choice and thus determine the ultimate form of cultural expression. The maturity of the present approach is attested by the steadily growing applicability of its results to a better understanding of ourselves and of the problems of our Western civilization.

ARCHAEOLOGY[13]

During recent years there have been certain healthy trends developing in the archaeological field. Although archaeologists are still painfully aware of the inadequacy of their data and are consequently prone to be ultraconservative in their attempts to avoid overfacile and unfounded generalizations, they show a growing tendency to interpret their results against a broader background than that of their strictly local and technical operations.

These attempts fall into two main classes. On the one hand, there is the recognition of archaeology as a technique of historical research, ably presented by Childe,[14d,e,f] in which legitimate deductions as to the development of culture and civilization are made according to the evidence at hand. Further extensions of this approach lead directly into the analysis of protohistoric periods and the

consequent linking of prehistoric and historic cultures into a broad and understandable pattern.

On the other hand, there is the recognition of archaeology as a technique of ethnology. This view is implicit in the concern which several archaeologists have exhibited in their examination and discussion of the theoretical implications of their procedures.[14b,k,p]

In specific areas steady advances have been made. Most of these are specialized in nature and need not be treated here. For the most part they represent a refinement and more precise understanding of patterns and relationships already blocked out or postulated. In the Near East, for example, the chief interest centers in the attempts to establish chronologies and correlations between the sequences that have been worked out for the different areas. Perhaps the most significant excavations of recent date are those of Tel Hassuna[14m] in Northern Iraq, where several stratified levels of pre-Halaf date have been found under Halaf deposits. Pre-Halaf material has long been known from several sites, but this is its first occurrence in circumstances that furnish considerable data on the earlier phases of the Neolithic in the Near East.

For European archaeology the steady revision downward of the Iron Age dating has perhaps the most significance from the standpoint of history.[14l] A detailed monograph on the Neolithic cultures of Bulgaria has just been written by the late Dr. James Gaul and published by the American School of Prehistoric Research.

An excellent study of Pleistocene archaeology in southern and eastern Asia has been published by Movius.[14n] This not only gives geological correlations but also recognizes a large area of chopping-tool cultures contemporaneous with, and distinct from, the biface industries of the West.

In the American field there have been a few important developments and a steady increase in the elaboration of patterns already established. Of particular significance are the equating of the Teotihuacan culture with that of the Mayan Old Empire, or classic period, and the recognition of Tula not only as the Historical Toltec but also as the source of Mexican influence in northern Yucatan, thus affording a double correlation of the Mexican and Mayan sequences.[14j,q,r]

On a broader scale is the concept of a Meso-American archaeological sphere. Although this concept has not yet been clearly defined, it involves the recognition of an archaeological culture area, including the northern part of Central America and Mexico, which remained relatively constant throughout the changing cultures of the different periods. (*See* Kidder *et al.*, note 14.) The recently isolated Olmec complex is regarded by some not only as very early but also as one of the bases from which the Meso-American cotradition developed.

In Peru[14a] the coordinated study of the Viru Valley undertaken by six North American and two Peruvian institutions provides intensive data on a limited region. Archaeological sequences and settlement shifts are being definitively established, and a long period of preceramic culture has come to light, pushing the archaeological record back to still earlier dates.

In North America the formation of the Committee for the Recovery of Archaeological Remains represents an important step.[14c] This Committee was organized in 1945 to meet the emergency created by government flood-control and irrigation programs involving extensive dam-building and reservoir systems. Since major population movements, intensive occupation, and cultural development have always taken place along the world's waterways, the salvaging of archaeological remains from the areas to be flooded is of paramount importance. The evidences of culture history from many significant localities must be unraveled before they are rendered inaccessible or destroyed. The Smithsonian Institution is the agency in charge of this program, and its position is strengthened by a series of interdepartmental agreements with such interested parties as the National Park Service, the Bureau of Reclamation, and the Corps of Engineers. Cooperation with state and local organizations is being developed, and several archaeological surveys of threatened areas have already been made or are under way.

Although not a part of the River Valley Project, the excellent synthesis of eastern archaeology by Ford and Willey[14h] points up the significance of river valleys and geographical routes in understanding the development and diffusion of archaeological cultures and of the movement of peoples.

Other advances lie in the geologic dating of the Lindenmeier and other Folsom sites to the late Pleistocene or immediately post-Pleistocene epoch. This, taken in conjunction with the Minnesota and Tepexpan skeletons (mentioned below under "Physical Anthropology"), clearly establishes an early date for the peopling of America. Recent newspaper articles report finds in Nebraska which are dated to the middle of the last glaciation; authentic scientific information is still lacking.

In the Southwest the definition of subareas and regional differentiation continues, and the separation of Anasazi, Hohokam, and Mogollon cultures

seems well established. Migration drifts and continuities with the cultures of historically known peoples are being traced.

Just published work by Larsen and Rainey at Ipiutak, Point Hope, Alaska, has yielded new material and is pushing back the dates for the earliest recognizable influxes from Siberia.[14q, l, o]

PHYSICAL ANTHROPOLOGY[15]

A) Fossil man:[16] The discovery and publication of much new fossil material has thrown considerable light on the evolution of man and added new points of controversy. In Java additional finds of several *Pithecanthropus* specimens have clearly defined the general type and established its close relationship with the *Sinanthropus* specimens from Choukoutien. The appearance of an exceptionally large jaw fragment in lower Pleistocene deposits in Java called *Meganthropus paleojavanicus* by Weidenreich and von Koenigswald, and three huge primate teeth, presumably Pleistocene in date but recovered from the shelf of a Hong Kong drugstore and labeled *Gigantopithecus blacki* by the same authors, have brought up the question of giantism among man's early ancestors. This is a provocative view which is not accepted by all anthropologists, but which does have an element of possibility.[16c, m, n, o]

Homo soloensis from the upper Pleistocene Ngandong beds of Java can now be fairly interpreted as a later and more advanced form of the *Pithecanthropus-Sinanthropus* group. The view that Neanderthal man is an offshoot of the east Asiatic types has been advanced and is under discussion.

In South Africa the series of fossil finds of adult members of the *Australopithecus* group, begun by Broom in 1936 and still continuing, has illuminated the question of transitional forms in human evolution.[16a] The exact dating of these Australopithecinae is still uncertain; although many statements attribute them to the mid-Pleistocene, Broom maintains that it is still possible that they are Upper Pliocene in date. These adult specimens come from Sterkfontein (*Plesianthropus transvaalensis*) and Kromdraai (*Paranthropus robustus*) and exhibit both human and apelike characters in the dentition, face, and skull. Long bones and more recent unpublished material indicate an upright posture, and the circumstances of their finding suggest a troglodytic and cooperative form of life. The range in cranial capacity is from 480 cc for *Plesianthropus* to 650 cc for *Paranthropus*. The actual significance of these Australopithecinae must wait until some specimens are found in deposits that can be accurately dated. If a Pliocene date should be established, it might not be necessary to eliminate them completely from the human line or to treat them merely as instructive and analogous offshoots.

In western Europe little new has been added to the alleged finds of the Early Palaeolithic since the discovery of the Swanscombe skull in 1935.[16b, g] This specimen came from an Acheulean context, and, in the view of many, its close resemblance to the Piltdown and Galley Hill skulls lends these earlier and disputed finds an increasing aura of respectability. This interpretation is, however, not universally accepted. The general implication is that a morphologically advanced type of early man existed in western Europe at a time level in which the inhabitants of eastern Asia were in the *Pithecanthropus-Sinanthropus* stage. While more such material is required for the elucidation of this interpretation, in the view of this writer the geographic distribution of core- and chopping-tool cultures lends added credibility. Recent reports that Lower Palaeolithic man has been found in France may indicate that clarifying evidence is at hand.[16k] At the cave of Fontéchevade, Charente, a modern-type skull was found associated with Tayacian implements sealed beneath a stalagmitic layer.

Neanderthal remains have now been reported from Baisun in Uzbekistan[16l] and from Tangier in Morocco. The divergent Neanderthaloids found in 1932 at Mount Carmel in Palestine have been published in detail.[16h] Whether these represent transitional forms or hybrids is still in question, but the tendency at present is to regard them as a hybridization between progressive and conservative Neanderthal forms or between conservative Neanderthaloid and more advanced types.

In America the recent find of an essentially Indian type at Tepexpan[16d] in Mexico is dated as Upper Pleistocene. In conjunction with the Minnesota[16e, f] skeleton, it not only adds confirmation to the archaeological evidence for an early date for the peopling of America, but it also supports the interpretation drawn from the finds of Asselar, Grimaldi, the Upper Cave at Choukoutien, and the like, that the differentiation of modern races was well under way during the late Pleistocene period.

B) Special studies: Some work is continuing along the lines of racial analysis in an attempt to define physical types and their distribution. Perhaps the most important recent work of purely descriptive character is the identification by Field of the Iranian Plateau variant of the Mediterranean race.[17]

Most racial studies at the present time, however, are more concerned with stability and inheritance patterns of the types present; populations are treated more as units, and the racial aspect is being studied in relation to historical, environmental, and genetic considerations.[17] Partly in reaction to the misapplication and abuse of the racial concept in recent years, many anthropologists are challenging the importance and significance of racial difference and are turning their attention to other facets of interest in the biology of man.

Among present trends is an effort to throw more light on human genetics.[18] This is being done through family studies of specific characters and by analysis of anthropometric data recorded for populations, the studies of blood types and their inheritance,[19] and by laboratory experiments which test the limits of genetic capability for development in bone growth as they are affected by muscular conditioning. One of the subsidiary goals of this approach is its application to the history of human development and the extension backward in time of our understanding of genetic processes.

Another area of research interest is in the arena of growth and ageing studies.[20] Normal development and variations caused by special conditions such as diet, environment, and pathology are receiving special attention. This field is making contributions to both pediatrics and orthodontics.

Perhaps the most highly controversial field in physical anthropology at this time is that of constitutional anthropology, or the anthropology of the individual.[21] The Kretschmerian view that there is a correlation between recognizable morphological and psychological types has been reassessed and elaborated by Sheldon and others. In its present form this concept is expressed in terms of three physical components which stem from the embryological layers known as the endoderm, mesoderm, and ectoderm. Labeled endomorphy, mesomorphy, and ectomorphy, all three components are present in varying degrees in each individual. The chief contribution of this new approach is the development of a rating scale and technique by which the relative strength of each component is assessed for each individual, thereby permitting the recognition and definition of intergrades between the rarely-occurring extreme types. A similar scale has been devised for rating temperament, and a high correlation between the two has been reported.

Although considerable effort is still being expended on clarification and refinement of technique and although this approach has not been adequately tested in cross-racial, cross-cultural, and other contexts, it is already being used operationally in its application to clinical medicine and to some extent to personality adjustments in industry, to problems of military equipment, and to sociological and demographic data.

This whole school is being subjected to violent criticism by many anthropologists who believe that its concepts are untenable or that its techniques are unsound. If the approach can be validated, however, its potential utility and general implications are far-reaching and of the utmost importance.

Less significant but also worthy of mention is one further aspect of physical anthropology. This is the application of anthropometric techniques to specific problems of design. During the war anthropometry was utilized to define range of variability, averages, and size frequencies of bodily measurements as a basic element in the design and production of clothing and equipment. It is being used in a similar manner by various industries today.

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The following bibliography is by no means complete and is intended merely as an orientation in the type of work now being done. Articles of special interest have appeared in numerous journals dealing with anthropology, archaeology, sociology, psychology, genetics and heredity, biology, physiology, and medicine; in the transactions of various academies; in the bulletins of numerous institutions; and in various monographs and special studies. The bulk of the recent literature is such that no adequate summary is possible.

There are several new works of an introductory nature. Of these the most satisfactory is Kroeber's masterly revision of his *Anthropology. The Ways of Men,* by John Gillin, emphasizes a functionalist approach, and *Man and His Works,* by M. J. Herskovits, stresses the cultural relativist point of view. Both are comprehensive. *Social Organization,* by R. H. Lowie, although more limited in scope, is thorough and valuable.

For physical anthropology the revised edition of *Up From the Ape,* by E. A. Hooton, is the most complete up-to-date survey.

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THE FREEDOMS

Speak not to us of freedoms in the large,
Nor chisel words to just the proper bevel;
Assume your closer and more pressing charge:
Let us have freedoms at the local level.
Do you find malice in your quiet town?
Is there compassion in your hustling city?
Men of good will, or tyrants trampling down?
Anonymous aid, or patronizing pity?

The things we need are very simple things:
Respect for human life and honest labor,
A proffered hand—no prompting from the wings,
A better casting in the role of neighbor.
Freedom has fled from many a hostile quarter,
Blurred are the freedoms written on the water.

KATHARINE O'BRIEN

BOOK REVIEWS

THE RACE BETWEEN EDUCATION AND CATASTROPHE

No Place to Hide. David Bradley. xviii + 182 pp. $2.00. Atlantic-Little, Brown. Boston.

ONE OF the skull-cracking problems of this atomic age is to assess properly its hazards. The devastation that an atomic bomb can cause has been emphasized over and over again. It has been said that the atomic age has made war intolerable because atomic bombs are too terrible to be used. If fear alone could prevent atomic wars, then the post-Hiroshima tradition of stressing atomic-bomb damage should be continued. But the problem of atomic energy control cannot be solved through fear. Like all other large problems, it can be met successfully only through level-headed study and discussion. The need that some have felt for stressing the potential disaster of atomic bombs is now clearly overshadowed by the necessity for clear thinking in the entire atomic energy field. Our success not only in avoiding the possible destructiveness of atomic energy but also in realizing its possible benefits will be measured by the extent to which the general public can accurately appraise its potential in either direction.

In *No Place to Hide,* Dr. Bradley unfortunately continues the tradition of stressing the hazards—in this instance, the radiation hazard during and following an underwater atomic-bomb explosion. Imbued with an admirable desire to let the public in on Bikini, he has written an absorbing chronicle of his experience as a "radiological monitor" with the task force that made the tests. If it were no more than that, the book would be superb. His account of the moments in a PBM-5 during the explosions and his flights over the target area as soon as possible thereafter makes good reading. There is much interesting detail about the islands of Bikini, Kwajalein, and Ebeye, on which he was based, interspersed with the routine of preparations and rehearsals.

The book is, however, more than a chronicle. It is also a continuation of part of his mission at Bikini: to convince people of the dangers of radiation which are "evident only upon the dial of some 'Geiger machine'." If the readers of this book are not already convinced after the stories of Hiroshima, they will be before they finish it. But even though Dr. Bradley states quite properly that "The danger from radiation, like the danger from sunburn, snake poison, strychnine, or almost any other hazard, is merely one of degree," readers are likely to feel that any radiation is to be avoided at all costs under any circumstances. For example, they will have read of a sailor who almost had a high amputation of his arm because of a suspicion of radioactive contamination in a minor laceration at the base of the thumb. They will have been led to believe incorrectly that such drastic action would be justified had the wound shown the slightest effect on a Geiger counter. This exaggeration of the seriousness of a radioactively contaminated wound makes it more difficult to acquire the level-headed perspective that is so urgently needed.

It is to be hoped that subsequent literature in the atomic energy field will be equally readable, but will contain as accurate an appraisal as possible of the various kinds of hazards about which readers of this book are left to wonder.

PHILIP N. POWERS
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Washington, D. C.

THE CONTRIBUTION OF LYSENKO TO BIOLOGY

The Science of Biology Today. Trofim Lysenko. 62 pp. $1.25. International Publishers. New York.

IN THE past few months, many articles have appeared, both here and abroad, in the newspapers, scientific journals, and magazines concerning the address of T. D. Lysenko before the Soviet Academy of Agricultural Sciences on July 31, 1948. This book is a translation of that address, and it is not hard to see why so much controversy has been stimulated as the result of its circulation, coupled with the many rumors of the change in viewpoint on genetics in the Soviet Union. It is a familiar phrase to say that any book is an absolute essential for biologists, but to apply such terminology in this instance is an understatement. Nothing in recent years has stirred up so much controversy, and it is important that this address be read by anyone who claims to be informed on trends in biology, particularly students of any phase of evolution.

It will be difficult for scientists to cope with the political dogma that occupies so much of the address. The familiar precise language is intermingled with political philosophy, and a careful reading is necessary in order to sift out the desirable material. Basically, the address contends that the materialistic Michurin trend in genetics is to replace the idealistic reactionary Mendel-Morgan-Weissman theory which is so deeply entrenched throughout the world. Not only is this Lysenko's contention, but by decree it is now the official Soviet viewpoint. It sounds fantastic that our whole concept of heredity, that the efforts of generations of geneticists, that the results observed on thousands of plants and animals, are all set aside by such action, but it is a fact. It will come as a surprise to many geneticists to hear their efforts designated as idealistic, reactionary, and the like.

Stripped of its trappings, the Michurin-Lysenko doctrine is what has been called the inheritance of acquired characters or, as Lysenko expresses it, "changes in the conditions of life bring about changes in the type of development of vegetable organisms. A changed type of development is thus the primary cause of changes in heredity." Expressing it again, he maintains that "Heredity is the effect of the concentration of the action of external conditions assimilated by the organism in a series of preceding generations." Lysenko asserts that this concept is based on Darwinism by saying,

> The Michurinists, in their investigations take the Darwinian theory of evolution as their basis. But in itself, Darwin's theory is absolutely insufficient for dealing with problems of socialist agriculture. That is why the basis of contemporary Soviet agrobiology is Darwinism transformed in the light of the teaching of Michurin and Williams and thereby converted into Soviet creative Darwinism.

When asked if such ideas had official approval, he replied, "The Central Committee of the Party examined my report and approved it." That statement explains more than anything else why experimental evidence can be treated with such great abandon.

The necessity for reading this book is not wholly that is represents another viewpoint of genetics, at least from its sponsor's standpoint, but because of the way in which it is being supported. The conclusion shows that very fully (author's italics):

> Progressive biological science owes it to the geniuses of mankind, Lenin and Stalin, that *the teaching of I. V. Michurin has been added to the treasure-house of our knowledge, has become part of the gold fund of our science.*
>
> Long live the Michurinian teaching, the teaching on how to transform living nature for the benefit of the Soviet people!
>
> Long live the party of Lenin and Stalin, which discovered Michurin for the world and created all the conditions for the progress of advanced materialist biology in our country.
>
> *Glory to the great friend and protagonist of science, our leader and teacher, Comrade Stalin!*

R. BAMFORD

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THE SEARCH FOR TRUTH

Economic Man. C. Reinold Noyes. 2 vols. xxiii + 1,443 pp. $15.00. Columbia Univ. Press. New York.

THE reviewer would like to stay around for another half-century to observe the fate of Mr. Noyes' *Economic Man,* to which fate he must perforce now make his small contribution. For the two stout volumes belong to the curious category of the immensely learned, the more or less original, and of works which, except to a Hindu philosopher or perhaps the mythical Martian observer, would seem to depart abruptly from the expected in our culture. Some of such books eventually win over their public; others, because of their very eccentricity and the genius or open-mindedness they demand of their readers, fall into permanent neglect. It would be a shame if the fruit of seventeen years of labor, of masterly synthesis and keen analysis, were to be fated to such neglect, but one would not care to bet heavily that it will not.

The basic objection of the author to classical economics is that it has not even loyally stuck to the elaboration of its formula "wants, efforts, satisfactions," but has allowed itself to give less than its due to process, and more attention than is proper to static physical objects, such as those lumped together under the rubric "land." His basic plea is for marshaling everything that all the pertinent sciences can contribute to a real understanding of man's "wants, efforts (or, alternatively, "means"), and satisfactions." In reality, his two series of terms differ only as to whether means are viewed as given, or as involving an effort necessary to provide them or bring them to the point where they can be effortlessly used.

If one starts (naïvely or pedantically, as you wish) with man, the creature with wants, it is evident that economics is in a sense a biological science. So are all the social sciences, and also linguistics, literature, the fine arts. It may be asserted that if they remain tied to their biological starting point they will never develop very far. Mr. Noyes' reply to this criticism is that if one is to arrive at an adequate explanation of man, one must start at the starting point, with man as organism. Such a start has the additional merit of helping us to be objective, analytic, and quantitative about ourselves.

At any rate, the data of the biological sciences have impressed the author with their certainty and exactness, and he spends his first 500 pages in summarizing them, to the dismay, doubtless, of his readers in economics. For this reason, the book should be reviewed by a committee representing neurology, physiology, psychology, etc., as well as economics. It is, however, precisely Noyes' point that all these matters *must* be brought together in a single mind, and that the compartmentalization which brings it about that biologist and economist do not speak the same language, do not understand each other's jargon, is totally nefarious.

In so far as economics rests on biology, "the data . . . must be accepted as they stand. The facts are unchangeable." In the technology and the social organization which man builds within the limits of the given and the possible, there is more freedom, and economics tends to become "the useful art of economics."

The necessarily bulky evidence of the author's long work, with its burden of quotations, footnotes, graphic representation, and appendices, begins with the "solid rock" of man's physiological wants and mechanisms, and progresses to the study of preferences, of costs, value, and demand. Sherrington, Woodworth, and Pavlov play as important roles as Pareto, Walras, and Clark. It is in homeostasis of the blood that Noyes finds the key to wants, for wanting is essentially the

search to recover a balance that has been somehow disturbed. Wants then produce "central states" (others have called them drives or urges or impulses or emotions), which require integrated action with the end of correcting variations from homeostasis.

The external observations of experimental psychologists add their proof that "mature animals have learned to suppress the consummatory reaction to any internal want which requires an external object for satisfaction until that object is present," a fact which is allied to "the gradual diminution in the relative importance of the repertory of instinctive behavior, as we proceed along the phylogenetic scale." In spite of this learning and suppressing we are, when we base ourselves on modern physiology, very far from the old hedonistic psychology and from the marginal utility theory related to it.

The changes called for in theories of psychological motivation and economic behavior Noyes says he cannot explain in less than his 1,443 pages, so certainly no review can do justice to them. Perhaps his own briefest and most illuminating phrase is that "the pattern of behavior . . . is . . . one determined by the relative intensity of future wants." The emphasis throughout is not on environmental stimuli to which we respond but on internal variations from homeostasis which set up corrective responses and so energize behavior. In pursuing the satisfaction of the wants that arise from blood and brain, we meet the resistances imposed by nature. Resistance is a truer concept than either "land" or "scarcity," and in Noyes' view is his most original contribution. It can be made quantitative, and Noyes affirms its usefulness in his own economic analyses; it leads to better understanding and to a limited degree of predictability.

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ON PINIONS FREE

The Flight of Birds. John H. Storer. xv + 94 pp. 176 figs. $2.50. Cranbrook Inst. of Science. Bloomfield Hills, Mich.

THIS pretty little book, despite many limitations, is the best discussion of bird flight available, in print, in the English language. The photographs of birds in flight and the diagrams of wing and feather structure should appeal to a wide audience with biological interests. For there is scarcely any attempt in the whole array of contemporary "bird books" to explain how a bird manages to fly. The sections devoted to soaring are the strong point of this book, especially Storer's descriptions of his own observations of soaring condors and hawks. It is one of the first books where an ornithologist accepts wholeheartedly the fact that a bird can soar only by means of rising air currents or velocity gradients. Gone are the nostalgic hints at a belief in levitation or some mysterious force which the older naturalists postulated to lift the birds they observed flying on motionless wings. Woodcock's important observations of soaring birds over the ocean are ably summarized, and so is the subject of slots and flaps in bird wings and their action as antistall devices.

The first portion of the book, however, is less clearly an asset to biological literature. On the basis of 16-mm motion pictures, an explanation is offered of the aerodynamics of the flapping wing, a thorny field where angels might well fear to tread even though armed with the best of data. As stated in the book, "In a feather at rest, we see not the shape that will be used in flying but a design that will automatically achieve (far different) shapes in response to different pressures from the air." Yet in this short treatment several rather dogmatic statements are made without qualification. For instance, "The outer half of a bird's wing, starting at the wrist, constitutes the propeller," and "the inner wing . . . is merely the handle that moves the propeller." These and other statements *may* be valid generalizations, but the figures do not establish them as such, nor does any other evidence known to this reviewer. Beyond the danger that the average reader will interpret many of the statements as established facts, when they can scarcely be more than plausible guesses, there is some confusion of thought and an apparent neglect of the European literature.

On page 28 one reads that "On the upstroke the wing tip moves upward and backward. By thus thrusting backward against the air it still drives the the bird forward." This implies that the wing tip moves backward on the upstroke not only relative to the bird's body, which is obvious, but also *relative to the air*. The latter is not true for most birds in forward flight, as can be seen in the figures on page 32. Thus the phrase "thrusting backward against the air" is misleading. At cruising speeds the whole bird is usually traveling fast enough so that relative to the air its wing tip always moves forward along a wavy path roughly like a sine wave. Pettigrew made this point eighty years ago, and Marey confirmed it by photographic methods. Perhaps the purpose of a discussion of the aerodynamics of bird flight might better have been served by translating selections from Stolpe and Zimmer's book, *Der Vogelflug* (Leipzig, 1939), or even by reprinting the remarkably lucid and accurate material in Pettigrew's *Animal Locomotion* (New York, 1874) or Marey's *Le Vol des Oiseaux* (Paris, 1870).

But the truly regrettable inadequacy is not in this little book, which scarcely pretends to be a thorough analysis of bird flight (except in the jacket blurb); rather it is the fact that so important a biological phenomenon as bird flight has received so little and such casual attention. Small birds at least could probably be trained to fly in a wind tunnel and the details of wing action photographed at close range. With clear pictures to determine the actual shapes and velocities of various parts of the wing throughout its cycle of movement, the aerodynamics of both flap-

ping and gliding flight could be described and analyzed far better than will ever be possible from motion pictures or visual observation of birds flying in the open. Here is a real opportunity for some experimental zoologist to break important new ground.

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UNIVERSAL RAW MATERIAL

The Coming Age of Wood. Egon Glesinger. 279 pp. Illus. $3.50. Simon & Schuster. New York.

"WOOD," asserts Dr. Glesinger, "will become the characteristic raw material of our civilization because it has three attributes which make it unique among all raw materials." It is universal. It is abundant. And it is inexhaustible.

He should know. Forests and their products have not had a more eloquent and enthusiastic champion in our time than Egon Glesinger. Now chief of the Forest Products Branch of the Food and Agriculture Organization, he came to the United States in 1941, having been forced by the Nazis to leave Europe, where since 1933 he had served as secretary-general of the International Timber Committee, originally sponsored by the League of Nations. Although a keen student of modern wood technology, his conception of the possible contributions of wood in all its physical and chemical aspects to man's welfare is that of an economist.

Fairfield Osborn's *Our Plundered Planet* and William Vogt's *Road to Survival* have conditioned us to think of land and resources from a global viewpoint. Glesinger's book beautifully supplements these splendid works by directing our attention to a particular kind of land and a particular kind of resource. Forests cover about 8,000 million acres, one fourth of the land surface of the earth. Although not all the world's forest resources are usable in a commercial sense, still only a fraction is utilized even after centuries of exploitation.

That wood as a raw material has satisfied many human requirements since earliest antiquity is a fact which it were almost platitudinous to repeat. But that wood as a raw material is capable of satisfying almost every requirement of existence is one of Glesinger's statements that will doubtless inspire some disbelief. But no scientist, or intelligent layman for that matter, should challenge the author's assertion without reading him and thus giving him an opportunity to prove his thesis.

We have long known that wood supplies shelter and fuel, that it produces food for men and animals. It is the world's second most important source of textile fibers. It is capable of supplying enormous quantities of motor fuels and lubricants. From wood come plywoods, plastics, paper products whose number is legion, and chemicals whose diversity and possible application are almost beyond our calculation.

> Tree extraction [says Glesinger], though practiced since the dawn of history, is still in its infancy. Yet of all the processes of forest chemistry, none is more suited to the nature of the growing tree than the extraction of the substances trees produce as living organisms. If all the extracts from all the world's trees were captured, they would add untold variety, color, and wealth to the arsenal of chemicals upon which mankind must be able to draw to achieve higher standards and well-being.

The shocking waste of wood, both in logging and in manufacture, by American forest products industries is an extravagance about which the author, with his European background of conservative utilization, is understandably critical. He makes a convincing case for integration of industry to end unreasonable competition for resources and to obtain closer utilization of raw material, including so-called waste products. He insists that in the interest of more equitable distribution of the wealth derivable from mass production of our forest resources for the benefit of all people, industry must rely more on technology and less on cutthroat competition. To obtain the complete utilization he deems necessary would require such radical reorganization of the forest industries as may be wholly impracticable in this era of still fairly abundant, though declining, resources. Still, he is able to show examples of such integration, not only in Scandinavia under the impact of economic and technologic development and in the Soviet Union under political five-year plans, but in the United States as well, where several large, financially secure, and family-dominated concerns have successfully integrated their production and forest-management operations. In short, it can happen here because it is happening.

That forest destruction is manifestly against the public interest is demonstrable fact, and it has been studied, and inveighed against, by the forestry profession for more than half a century. The solution of this problem, as Glesinger sees it, is public, that is to say Federal, regulation of private forest management by law. In this proposal he echoes the efforts and agitation of a long line of public officials, beginning with Gifford Pinchot and including Franklin D. Roosevelt, the last three chiefs of the U. S. Forest Service, and, most recently, President Truman. That public regulation of private forest management has been successful in certain European nations cannot be adduced as a reason for its imposition here. This is not to say that it won't work here; this reviewer merely desires to point out that under our democratic system the principle of Federal regulation has simply not become a Congressional issue, and not entirely because of opposition by the so-called forestry industry lobby. Dr. Glesinger is a distinguished forest products economist, not a professionally trained forester, which are two different things. Thus it is no disparagement whatever of his book to suggest that he is more convincing in his advocacy of intensi-

fied research and industrial integration than in his plea for silviculture by law.

This book is worthy the earnest attention of every American who may have the least interest in the role which modern technology applied to forest resources may play in increasing industrial prosperity and human comfort.

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THE MEANING OF ANTHROPOLOGY

Mirror for Man. Clyde Kluckhohn. xi + 313 pp. $3.75. Whittlesey House. New York.

THE title of this book, which took first prize ($10,000) in a publisher's contest for scientific books last year, is especially apt. Anthropology, as the science of man, includes a vast range of material. Professor Kluckhohn has superbly presented a reflection of the scientific picture of man in his totality. Like any mirror image, there is a surface completeness, with very limited detailed. This is, however, necessary to the purpose of the presentation. As clearly stated by the author in his preface, "This book is intended for the layman, not for the carping professional. . . . Had I entered all the qualifications and reservations required in a technical study, the intelligent layman would stop before the end of the first chapter."

Any professional anthropologist who has tried to convey to the layman the meaning of anthropology as a science, and its application to the world of today, must appreciate the clarity and easy communicability of the author's presentation. The teacher who has tried to summarize an introductory course in general anthropology will find this book an outstandingly desirable one for reference to his students. It is an ideal companion to any text in the field.

The first seven chapters which present summaries of ethnology, archaeology, physical anthropology, and linguistics, together with their applications in the past and present, and their interrelations with one another, are outstanding in this latter connection.

The eighth chapter, entitled Personality in Culture, presents a conservative picture of the time-honored anthropological concern of the interinfluences of the individual and the group. There is also some attempt to give a picture of the various psychological approaches being used in this special field today. The reviewer feels that the author has perhaps been overcautious with respect to this latter portion of the subject.

The two final chapters, An Anthropologist Looks at the United States and An Anthropologist Looks at the World, are statements of the potentialities of the science in analyzing contemporary cultures on broad bases. Here we find a picture of what anthropology has done in this field in the past, what it is doing today, and what it may be expected to contribute in the future. They are the least satisfactory chapters in the book, because many of the points made explicit here have been more strongly presented by implication in the preceding portions of the volume. Nevertheless, they are correctly included in a book of this kind.

The book is interestingly written, absorbing, and eminently successful in achieving its purpose. It fills a long-standing need in scientific literature for the layman.

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FANCY AND FACT

The Lungfish, the Dodo, and the Unicorn. (Rev. ed.) Willy Ley. xi + 361 pp. Illus. $3.75. Viking. New York.

IN THE introductory chapter to this "excursion into romantic zoology," Willy Ley outlines the literature of natural history from Aristotle and Pliny, through Gesner and Linnaeus, to Cuvier, Buffon, and Darwin. But in tracking down legends of animals that never existed, such as the unicorn and the dragon, he has gone through an enormous amount of classical and medieval writing, and assembled his clues with as much suspense and thrill as would the writer of a modern "who-dun-it." The unicorn can be blamed, in part, on a mistranslation of the Old Testament from Hebrew into Greek; paleontology has substituted the woolly mammoth for some of the giants of legend; and philologists have offered interesting linguistic explanations for such myths as those of birds that grow on trees.

The first part of the book deals with animals that never existed; the second part tells of animals that actually lived but are now extinct; and the third part, Witnesses of the Past, treats of bizarre creatures of ancient origin which, had they followed the pattern of their kind, would be extinct today. The chapter As Dead as the Dodo points out that the bird really became well known only after its extinction; for about a hundred years Dutch and Portuguese navigators brought stories of it, and occasional specimens, back to Europe, but when naturalists went to Mauritius to look for it, it had vanished so completely that residents of the island doubted that it had ever occurred there.

New Zealand Interlude is a delightful chapter on the fauna of a region where ancient species have maintained themselves by being isolated from invading enemies. The Ituri forest in the Congo, another lost world, is the home of creatures that really should be fossils by this time, such as the okapi and the pangolin. In contrast to these survivors, who have been protected either by island or forest isolation, Ley points out that Limulus, the "horseshoe crab" of the North American Atlantic Coast, has three claims to fame: "First, it is one of the oldest living animals; second, it is probably the most numerous

living fossil; and third, it has survived not on some carefully isolated and protected island but in the open sea."

Out of the mass of data that Ley has presented with contagious enthusiasm, I have found one or two minor inaccuracies. The orangutan is not extinct in Sumatra—I obtained a fine large specimen there in 1937. And in 1948 I saw a sizable group of Heck's reconstructed "wild forest horses," which managed to survive the repeated bombings of the Munich Zoo.

In Rumors and Shadows Ley has collected many fascinating native tales of animals unknown to science. As he retells the story of the comparatively recent findings of the okapi and the pigmy hippopotamus, and of Jimmy Chaplin's melodramic search for, and discovery of, the African peacock just a few years ago, one realizes that in African or South American jungles there may still be even larger animals yet to be found.

This new and enlarged edition of a previously published book is so delightful and well done that the reader is glad to have it again available.

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SCIENCE AT THE SOURCE

A Source Book in Greek Science. Morris R. Cohen and I. E. Drabkin. xxx + 597 pp. Illus. $9.00. McGraw-Hill. New York.

Studies in Philosophy and Science. Morris R. Cohen. 278 pp. $4.50. Henry Holt. New York.

IT HAS been the glib intellectual fashion for some time to award the ancient Greeks the palm for preeminence in art, literature, and philosophy, but to say that Greek science, because the Greeks lacked machines and precision instruments, was a rudimentary and retarded affair. The *Source Book,* a selection of Greek writings on mathematics, astronomy, mathematical geography, physics, geology and meteorology, biology, medicine, physiological psychology, and chemistry, refutes that view. It also serves as a positive reminder that the basic requirements of science are a seeing eye, a hearing ear, and a talent for speculative theory—attributes which the Greeks had in surprisingly modern degree.

Professor Cohen, one of the two or three most dynamic influences in recent American philosophy, was an ideal choice for co-editor of the *Source Book.* As appears from his *Studies in Philosophy and Science,* he is primarily in the Greek philosophical tradition; and, interested though he was in all facets of learning, his basic predilection was for the Greek-born disciplines of mathematics and the natural sciences. In fact, Professor Cohen's concurrent grasp of recherché philosophy and mundane scientific matters is in the best Hellenic tradition. Aristotle, it may be remembered, contributed to Western civilization not only the classic canons of deduction and incidental insights on such matters as the sphericity of the earth, and the role of slipping of earth masses and subterranean gases in earthquakes, but also astounding observational detail, classificatory technique, and the teleological approach to human and animal biology, zoology, and psychology.

Dr. Drabkin, co-editor of the *Source Book,* who has translated the hitherto untranslated passages in this compilation, is a professor of mathematics.

Unlike the technical virtuoso in a special field, Professor Cohen is interested in the basic problems of scientific method rather than, let us say, some dazzling notational exercise, an interest which lends stimulation both to the *Source Book* and the collection of *Studies.* The *Source Book* implicitly, and the *Studies* explicitly, demonstrate the simple and elementary nature of the fundamental ideas and advances of science. Such a realization should give the scientist a humility that is vitally needed in our braggart and technically proud civilization. Furthermore, no student of Greek culture can escape, even in the scientific field, the feeling that Greek thinkers and scientists were in the service of the Greek political states, voluntarily as free men and not in the servile Nazi or Soviet fashion. (I wonder how the formulator of the Hippocratic oath would vote on the Compulsory Health Insurance Bill?)

There are excluded from the *Source Book* the myths, superstition, and astrology that occasionally characterize even some of the soberest Hellenic chroniclers of science. The main effort of this volume is to achieve comprehensive coverage of topics: in 558 pages of text, it is the rare selection that takes up more than 5 pages, and a great many occupy only a half page or page of print. Furthermore, the authors have shown commendable asceticism in confining their notes and footnotes to the essential task of clarifying their texts and putting them in their historical setting, and have refrained from overexercising their philosophic erudition. Readers who desire to gain broader or more intensive insights can, however, consult the valuable 10-page bibliography at the end.

Professor Cohen's views on the nature of the physical world and the mathematical and physical sciences are set forth more comprehensively in his earlier volume *Reason and Nature.* In the current *Studies,* students of science will enjoy his slashing attack on Francis Bacon as a shallow scientific amateur who propagated the fallacy that observation unaided by theory can result in knowledge; and his respectful but firm and meticulous analysis of why he—as a man primarily interested in the nature of the world—must needs differ from the anthropomorphically minded John Dewey. Unlike John Dewey, Professor Cohen's criterion of "truth" is not pragmatic success in achieving human ends, but a logically consistent system setting forth with maximum simplicity and directness relationships among objective entities. Thanks to Charles Peirce, these relationships are not invariant, but admit of chance deviations. They are subject to the principle of "polarity"—i.e., the physical universe can largely be described as an equilibrium between contradictory principles or concepts.

The *Source Book* series is sponsored by the AAAS, among others, and it can be congratulated upon this volume on Greek science as a worth-while and durable work of scholarship and reference. Scientists without philosophic training can find food for thought even in the solely technical yet lucid philosophic essays in *Studies in Philosophy and Science.*

SIGMUND TIMBERG

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EXPLORING THE OCEAN DEPTHS

Submarine Geology. Francis P. Shepard. xvi + 348 pp. Illus. $6.00. Harper. New York.

DURING the second world war, submarine exploration in the coastal waters of the various war zones extended knowledge of the sea floors. In the course of these investigations, new methods for determining positions at sea and improved equipment for exploration were developed.

Submarine Geology summarizes the available information in a brief and readable text. The first five chapters survey the methods of exploration, waves and currents, shore lines and beaches. The descriptive classification of shore lines presented by Dr. Shepard is no more satisfactory than those he condemns, and its position in the volume breaks the continuity of the discussion of marine processes. If the whole purpose of shoreline classification is to enable a student to differentiate configurations due primarily to nonmarine and marine agencies, then the proposed classification may have some merit. Unfortunately, the geologist expects something beyond such a goal. A classification should not only differentiate between various features, but also should indicate interrelationships, possible antecedents, and future developments of a land form. The proposed classification fails to fulfill these requirements. Furthermore, Dr. Shepard's inclusion of irregular shore lines with small bays, prominent points, and stacks in a group entitled "sea cliffs made irregular by wave erosion" might well be challenged. As he himself so carefully illustrated in an earlier chapter on waves and currents, the headlands bear the brunt of wave action, whereas the estuaries suffer but minor attack. Does this fact not indicate that the irregular shore line is inherited from some other agency, and that it is but an ephemeral feature in geologic time? The sea's role is smoothing out irregularities, not making them.

The last seven chapters describe the principal features of the sea floors of the world. This portion of the book should be of interest to the landlubber geologist, who has little time to keep up with submarine exploration. It is to be regretted that the author did not begin this section with a description of the shore lines of the world, treating them in the same order as the material in later chapters—that is, by tracing them around the continents and islands. Such a treatment of shore lines might have made a desirable substitute for his dubious classification, harmonized with the balance of the volume, and provided some transition between the first and second parts of the book.

Although Dr. Shepard's interpretation of the origin or significance of the features described may in some instances be open to question, he is to be congratulated for briefly summarizing a large mass of data and for providing numerous references for those who wish to pursue any aspect of the subject in greater detail. The illustrations are generally adequate, despite the limited geographic range of the photographs. Unfortunately, the depths on many of the charts have suffered so much reduction in size in the process of reproduction that they are illegible.

Students and geologists will find *Submarine Geology* useful as a reference, though perhaps too brief to serve as the text for a course. It is hoped that future texts in this field will be more detailed than this pioneer endeavor and that integration between descriptions of different portions of the ocean floor and processes of formation will be more thorough. Brevity, if carried to extremes, may border on the superficial.

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MAN IN THE ANDES

Acclimatization in the Andes. Carlos Monge. xix + 130 pp. $2.75. Johns Hopkins Press. Baltimore.

CARLOS MONGE, one of America's outstanding scientists, has made the field of altitudinal adaptations in man peculiarly his own. His work is a fine example of the importance of exploiting the advantages of a local situation. Monge lives in Peru, where man has achieved the greatest vertical distribution in permanent habitation known on our planet, and it occurred to him to make detailed investigations of this situation, with results that are of interest to physiologists everywhere—that should be of interest, indeed, to all biologists and to students of the social sciences as well.

Unfortunately, I think, Monge makes only passing mention of contemporary work, whether his own or other people's, in the present book. It consists almost entirely of a study of the records and observations of the Incas and of colonial Spanish officials on the effects of change of altitude on individuals and populations, and on the recognition of these effects in folk customs and in social legislation. He is chiefly underlining the neglect of this subject in Peru since the country achieved independence, which gives the book a slant that was important for the local audience, but that has less relevance for the readers at whom the translation is aimed.

The accounts of the Incan customs are, however, fascinating enough in themselves, and serve as vivid evidence of the ways in which that complex culture

was adapted to its distinctive environment. A chapter on Altitude and Military Operations shows the disastrous effects that can result from ignoring altitudinal adaptations, as happened during the colonial wars. Monge has a slight tendency to use big words, like "climatic aggression" and "bio-climatic determinism," that have, to me, a confusing effect; and I wish that the historical account had served as an introduction to an account of his own observations and experiments in which his phraseology and theories could have been more clearly defined.

The book has a foreword by Isaiah Bowman, and the English translation by Donald F. Brown reads very smoothly.

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THE EUROPEAN FLAMINGO

Die Flamingos der Camargue. Etienne Gallet. 127 pp. 56 figures. Verlag Werner Krebser & Co. Thun, Switzerland.

IT IS strange that the flamingo, one of the most local and most striking in appearance of all the birds of Europe, has never been made the subject of a special monograph. This omission is now rectified by the appearance of this little book, and a very satisfactory account of the species it is. The flamingos are birds of great interest to naturalists from several angles, and have been the direct goal of many ornithological pilgrimages to the desolate marshes of the Camargue, the only part of France where these large fowl may be sought with any assurance of success.

The detailed account of the habits of the European flamingo given in Gallet's book and the excellent photographs that illustrate it make the volume a companion piece to the late F. M. Chapman's well-known paper on the life history of the American flamingo, published in 1905 by the American Museum of Natural History. As might be expected, the two species are essentially similar in their habits, although it appears that the truncated conical mud nests built by the American species are higher structures on the average than are those of the European one; it also seems that the young of the latter tend to gather in flocks earlier than do the chicks of the former species. These are, however, very tentative conclusions from a comparison of Gallet's and Chapman's papers, and may not be upheld by additional data of future observers.

The book is divided into two sections, one dealing with the life of the flamingos and the other with supplementary observations on special topics. The former section treats of the habitat requirements, the appearance and wanderings of the birds, their food, their pairing and family life, the duration of incubation, the growth and development of the young, and the enemies of the species. The second part, much shorter than the first, gives additional data on food, nests, eggs, a list of the known breeding colonies in the Camargue from 1914 to 1947, measurements of a series of specimens of the birds, and a useful bibliography. There is a short foreword by Professor Hediger, of the Zoological Park at Basel. The volume is handsomely made and attractive to look at. There is no index, but as the whole book is quite small this is not a great handicap.

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SMITHSON'S WHIM

Sons of Science. Paul H. Oehser. xvii + 220 pp. Illus. $4.00. Schuman. New York.

SO far-flung is the renown of the Smithsonian Institution, not only as a landmark in our nation's capital, but also as an international symbol of the importance and value of science, that it comes as rather a surprise to have it called to one's attention that were it not for the whim of a wealthy but lonely Englishman—who had never seen the United States —the institution would never have come into existence.

In 1829 James Smithson's bequest of money for the founding of an institution at Washington "for the increase and diffusion of knowledge among men," as stipulated in his will, was dropped so suddenly and unexpectedly into the lap of the Congress of the United States that it took this august body ten years to decide what to do with it. What has finally materialized is not a single institution but a whole family of them, far exceeding the dream of the original donor—and far exceeding the funds he provided as well. At present the Smithsonian family, partly supported by Congressional appropriations, consists of the United States National Museum, the International Exchange Service, the Astrophysical Observatory, the National Collection of Fine Arts, the Bureau of American Ethnology, the National Zoological Park, the Freer Gallery of Art, the National Gallery of Art, the National Air Museum, and the Canal Zone Biological Area.

In *Sons of Science,* Paul H. Oehser, since 1931 editor for the United States National Museum, and since 1946 assistant chief of the Smithsonian's Editorial Division, tells the colorful story of this cultural and scientific center. Through a description of the lives and activities of the men who directed its progress since its founding he relates how the institution was founded, how it was housed, how its various divisions were conceived, and how they thrived, reached maturity, and sired still other offspring.

In chronological order of services rendered, these men are as follows: Joseph Henry, famous American physicist and first director of the Smithsonian; Spencer Fullerton Baird, biologist, who is often called the

father of the National Museum; George Brown Goode, another biologist and a museum expert; Samuel Pierpont Langley, world-famous astronomer and pioneer in "flying machines;" Charles D. Walcott, geologist; Charles G. Abbot, astrophysicist; and Alexander Wetmore, well-known ornithologist and present Smithsonian secretary. Our national house of science, the Smithsonian, has indeed been the home of illustrious Sons of Science.

Slanted for the general reader, the volume should do much to eliminate our lacunae concerning this absorbing bit of American history. It constitutes a welcome addition to the "Life of Science Library."

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Los Angeles

NONINDUSTRIALIZED MAN

Man and His Works. Melville J. Herskovits. xviii + 678 + xxxvii pp. Illus. $6.75. Knopf. New York.

LIKE Herskovits' previous writings, this volume is an excellent job, well written, and represents a real contribution to the social sciences. The purpose of *Man and His Works* is summarized by the author as follows:

> As a scientific discipline, anthropology has amassed an impressive body of materials, and has reached substantial conclusions about the nature, processes and functioning of human groups and their modes of existence. It is these conclusions, and such of the factual materials as are necessary to document them, that form the core of this book. It is hoped that a unified treatment of the entire field of anthropology will be of aid in giving insight into the kind of world we live in, and why it is that kind of world (p. ix).

Separate sections are devoted to the presentation and interpretation of anthropological findings in the fields of the nature of culture; the materials, structure, and aspects of culture (including separate chapters on such topics as Technology and the Utilization of Natural Resources, Political Systems, Religion, etc.); cultural dynamics; and cultural variation. The last chapter, Anthropology in a World Society, attempts to portray the role which cultural anthropologists can play in an understanding of our present-day industrialized society. Practically all the anthropological materials introduced relate to "primitives" or "nonliterate" peoples from Africa, the Western Hemisphere, and Oceania; very few materials relating to Oriental cultures are introduced.

The title of this book, its stated purpose, and the chapter Anthropology in a World Society suggest an all-inclusiveness, so that the reader expects to find at least two subject areas covered more adequately than they are. The first is our modern industrialized Euro-American culture, in particular, as it is similar to and differs from nonindustrialized cultures; the second consists of the writings and findings of social scientists other than professional anthropologists. The author has followed the custom of most anthropologists by limiting himself to anthropology as conventionally taught in our universities. However, in so doing, it should be noted that the relationship between nonindustrialized cultures and our modern industrialized culture has not been adequately established, despite the author's statement that study of cultural anthropology ". . . will be of aid in giving insight into the kind of world we live in, and why it is that kind of world." He does attempt to differentiate cultural anthropology from sociology and the other social sciences; it appears, however, that he has demarcated cultural anthropology as a separate and distinct field of research and study only by limiting himself to societies other than our modern industrialized one.

By so limiting himself, he has written a book which discusses nonindustrialized man rather than *all* men and *all* cultures. The considerable amount of insight into the problems of our modern society that might result from a comparison of industrialized and nonindustrialized societies is largely missing. Also missing are many relevant findings from sociology and other social sciences. As a volume in the field of anthropology as commonly taught in our universities today, this book is excellent; in so far as it is claimed that cultural anthropology as distinct from the other social sciences has significance for our modern industrialized society, cultural anthropologists have yet to prove their case.

A. J. Jaffe

Washington, D. C.

MICROBIOLOGY

Microbes Militant: A Challenge to Man. Frederick Eberson. ix + 401 pp. Illus. $4.50. Ronald Press. New York.

The Biology of Bacteria. (3rd ed.) Arthur T. Henrici and Erling J. Ordal. xiv + 577 pp. Illus. $5.50. Heath. Boston.

THE common subject matter of these two books happens to be microbiology. Here their similarity ends.

The first of the books, by Dr. Eberson, assistant chief of the laboratory service in the Veterans Administration Kennedy Hospital in Memphis, Tennessee, is a revision of his earlier work, *The Microbe's Challenge*, published in 1941. It is essentially a popularized discussion of the rise of medical bacteriology and its role in preventive medicine.

In his opening chapter the author describes in simple terms what bacteria are, how they live and breed, their relation to disease, and how the human body attempts to ward off microbial attacks. Having thus introduced his subject, Dr. Eberson tells in lively fashion the now familiar story of how bacteria were discovered with homemade lenses by Antony van Leeuwenhoek in 1676 and how this discovery languished for more than a century and a half, until such men as Henle, Cohn, Pasteur, Koch, Lister, Tyndall,

Smith, and a host of other workers established the new science of bacteriology.

Still in a historical context, the story continues with a discussion of parasitism, in which the reader is introduced to a few nonmicrobial parasites, such as *Trichinella spiralis,* some insect vectors of disease, and certain protozoal and rickettsial agents of human misery. Then follow chapters on bacterial variation, bacterial chemistry and serology, viruses, bacteriophages, and antibiotics. The book concludes with a historical discussion of epidemiology.

This new version of Dr. Eberson's book has been enlarged to include many of the advances in our knowledge of infectious agents resulting from the war. The author is at pains to point out, however, that our ever-increasing stock of knowledge concerning microbes is no cause for complacency—that the problem of infectious disease is still very much with us and offers a continuing challenge to the human race. Dr. Eberson is to be commended for having produced an interesting and readable book useful to the general reader as well as to students of bacteriology and of medicine.

One last comment: On page 25, line 11, Leeuwenhoek is described by the author as having quit his job as a draper's assistant to become "*Kamerbewaarder der kamer von Heeren Schepenen van Delft.*" This Dutch sentence Dr. Eberson has loosely translated as "In other words, he was custodian or janitor of Mr. Schepenen's rooms." This is not quite fair to the Father of Protozoology and Bacteriology. A more precise rendition of this phrase indicates that *Heeren Schepenen van Delft,* means the Aldermen of Delft. Mr. Leeuwenhoek was in fact the custodian of the Council Chamber for the Aldermen of Delft, a somewhat different position from that of personal valet to the mythical Mr. Schepenen. This not only appeared in the first version of this book, it is repeated in this second edition. It is permissible to hope that Mr. Schepenen's ghost will have been laid to rest when a third edition of *Microbes Militant* appears.

The Biology of Bacteria, in contrast to *Microbes Militant,* is a straightforward textbook of general microbiology. Those who are familiar with the earlier editions of this book by the late Professor Henrici, of the University of Minnesota, will scarcely need an introduction to this revised edition. Suffice it, therefore, to point out that the new version admirably preserves the spirit of the original work. There are 83 more pages in the new edition as compared with the last; this does not indicate the extent of revision adequately, since the entire book has been redesigned and reset, so that there is actually more textual material than the increased number of pages might suggest.

The chapter on the microscope and microscopy now includes a discussion of the phase microscope, the electron microscope, and of ultraviolet and fluorescent microscopy; and it must be mentioned incidentally that some excellent electron micrographs appear as illustrations. Nine pages devoted to fungi in the second edition have been expanded to 21 pages in this one, reflecting the growing importance of this group of organisms. In so far as it could be done in an introductory text, the newest available data on every phase of microbiology, from bacterial metabolism to viruses and rickettsias, have been included.

Despite its general excellence, one gentle criticism of this book must be voiced. It is in regard to the absence of any list of additional readings. Any book written as this one is—on a beginner's level—tends to become dogmatic. In an effort to be all-inclusive, the authors fail to leave room for qualifying remarks. In such a case, one remedy seems to be to expose the student to a wider view of the subject through well-selected lists of references. Thus the student can more readily see the subject as in a state of flux and growth rather than as a static body of accepted dogma useful chiefly for passing examinations.

Morris C. Leikind

Library of Congress
Washington, D. C.

MARINE BIOLOGY

Between Pacific Tides. (Rev. ed.) Edward F. Ricketts and Jack Calvin. xxvii + 365 pp. Illus. $6.00. Stanford Univ. Press.

IN THE decade between the first publication of *Between Pacific Tides* (1939, reviewed in The Scientific Monthly, **50**, 274) and the appearance of this revised edition, the public has had unusual opportunity to learn something of the character of its senior author. As "Doc" in John Steinbeck's *Cannery Row* and as collaborator on that same writer's *Sea of Cortez,* the late Edward F. Ricketts has become known to a far wider circle of readers than most marine biologists ever do. In that same decade the original edition of *Between Pacific Tides* proved to be a stimulating introduction to intertidal invertebrates for the amateur and beginner, which is the avowed purpose of the volume, but in addition it has also become established as a useful handbook for the student of invertebrate zoology and ecology.

The changes appearing in the revised edition will, in the main, increase the book's effectiveness from the biologist's point of view by some additions and by bringing the references up to date. The bulk of the text, photographs, and drawings are nearly identical with the 1939 edition. Their arrangement, too, on a faunistic ecological plan, likewise remains unchanged. For this reason certain material in which one might have hoped for revision is still in its original state. In particular, some of the drawings, such as those of coelenterates, are scarcely deserving of the fine presswork and bookmaking that have gone into their presentation. The same is true of a few of the otherwise excellent photographs, mainly the work of the junior author.

The new material in the revised edition consists of a frontispiece in color; a new section of 34 pages,

including 17 additional figures, on plankton; and 12 pages of interpolations in the systematic and bibliographic appendix, which bring the latter up to 1947 in coverage. Most of the volume is written in a series of faunistically arranged paragraphs, each dealing with specific organisms. The additional material on Pacific marine plankton, however, forms a highly readable continuous account emphasizing the importance of the plankton community for the largely benthonic communities dealt with in the rest of the book. This section, with its bibliography and the new material in the appendix, should add considerable value to a book already proved to be very useful as an introduction to our Pacific coastal fauna.

TALBOT WATERMAN

Osborn Zoological Laboratory
Yale University

AVOIDABLE MORTALITY

How to Live Longer. Justus J. Schifferes. 255 pp. $3.00. Dutton. New York.

HEALTH education is a field in itself. The author of this excellent discussion of preventable and premature death has been active in this field for many years and, although not a physician, is fully qualified to write upon his subject. There are many approaches: statement of fact, pleading, and explaining the meaning of facts are three of the most useful. In the present volume, J. J. Schifferes has employed all three. The book is crammed full with facts, especially statistical and mortality data concerned with the major causes of death today. There are also much pleading to avoid unnecessary suicide by living more wisely, and some rules to follow. The facts are sound, the pleading is sincere, but the author, trying as he is to simplify the problem of avoidable mortality, cannot escape generalization and oversimplification.

There is too little explanation of the meaning and implications of some of his statements. It is true, he points out, that if more people avoided obesity by controlling their appetites, we would have less diabetes mellitus and therefore fewer deaths from diabetes. But this does not suffice. To be successfully guided, the obese person must know *why* he eats too much and to be assisted in resolving the anxieties which create the need for an escape mechanism in stuffing himself. Individualization and the personal touch are lacking. Throughout the excellent factual text one feels the author is thinking and dealing with "paper" men and women, digits in statistical tables. Similarly, his recommendations are largely on the "wholesale" level—public health agencies and organizations are to be the major factors in developing the utopia of longevity with health. Though there is adequate and repetitive emphasis of the need for assuming personal responsibility for one's health, it lacks conviction and one feels the author has an exaggerated faith in the intelligence, will, and emotional maturity of mankind. I do but wish mankind were sufficiently grown-up to follow intelligently the excellent and fundamental advice offered, even in general terms, but this is only a wish, and wishes are not convincing in science. The "scare" technique herein employed has repeatedly fallen short of expectations; tried as a crime deterrent, severe penalties have not reduced the incidence of crime; horror pictures have failed again and again to appreciably reduce promiscuity and therefore venereal disease. The author has studied the basic facts about disease and presents them well, but his understanding of men and women is remote, vague, idealized, and unrealistic.

There is much to be learned by a careful study of this book, and both good and bad can come of this work. Some few people will be stimulated to take better care of themselves and seek individualized personal guidance; others will be frightened, and their hypertensive disease or ulcers exacerbated. It is, however, recommended reading for those who seek facts.

EDWARD J. STIEGLITZ, M.D.

Washington, D. C.

FRESH FISH FOR THE ARMY

Fishing in Troubled Waters. Wilbert McLeod Chapman. 256 pp. $3.00. Lippincott. Philadelphia.

THIS is a narrative of the adventures of the vessel and the crew which undertook to provide fresh fish for the United States Army, behind the battle front in the Southwest Pacific, in the closing period of the war—written by the scientist in charge of operations. Though far from a scientific record, it provides interesting side lights on physiography, weather, and potential fisheries of the islands, not to mention personalities involved in the military organization, and of native islanders.

Bits of natural history are unobtrusively scattered through the book. There is an exceedingly interesting description of the tridachna ("maneater") clams in life, the larger of which might easily prove disastrous for one stepping by mischance into an open shell. The fish fauna in these waters is abundant and tremendously varied. By spreading derris root along the coral in shallow water at one point, diving after and securing the small fish as the poison began to affect them, 472 fishes belonging to 121 species were collected "in one small spot, no more than half an acre in area." We read that "Many of these were most peculiar, and they were generally much more highly colored than the fish with which we were acquainted in northern seas."

Food fishes of the reefs are notably difficult to secure in quantity, but it was such that were immediately available and had to be drawn on, especially surgeon fishes and parrot fishes, it seems. Though taken with nets, the former had to be handled with spears. "Because of the sharp folding spine on the base of their tail it is not possible to touch these fish while they are alive." "Almost all of the many kinds of parrot fish carry some bit of brilliant color about their persons, and many are a blaze of brightly con-

trasting hues all over. . . . Contrary to some medical opinion their flesh is not only not poisonous but is delectable."

Though the war was barely out of sight below its horizon, the book is a fascinating tale of adventure, replete with color, human interest, and typically American humor, whereof some exaggeration no doubt is a part.

J. T. NICHOLS

American Museum of Natural History
New York

BIOGRAPHICAL NOTES

The Life Story of the Fish, His Morals and Manners. Brian Curtis. xii + 284 pp. Illus. $3.75. Harcourt, Brace. New York.

THERE is probably no group of animals about which more questions are asked and answered less properly, or about which more misinformation is in general circulation, than fish. This unfortunate state of affairs comes about because man has always fished for one reason or another and because fishes, by the very nature of their medium, appear to be mysterious. Certainly they cannot be studied easily without more equipment than is readily available.

Brian Curtis' book should do a great deal to remedy these matters, for he has brought a tremendous amount of knowledge together and written it in as simple and engaging a manner as seems possible, all without compromising in the least the scientific principles by which the information was assembled.

It is hard to conceive how the whole feeling of the living of a fish could be better explained, from how a fish is born, feeds, grows, reacts and adapts to its environment, how it sleeps, and why, for many groups, it does what it does. Even such highly technical aspects of fish living as what it sees, and how, are treated completely and simply.

The principles and practices of conservation measures in fish management, of fundamental importance to the millions of anglers, and the effects of water conservation measures on both game and commercial fisheries are all brought under understanding scrutiny.

The absence of footnotes and reference marks makes for easy reading, and the inclusion of a "Selected References" section, by chapters, directs the curious to the proper authority for detailed information.

One or two small slips—for instance, the somewhat slack use of the terms "oxygenation" and "aeration"—do not detract seriously from the excellence of the book. It is by far the best popular exposition of fishes and their living we have yet seen.

CHRISTOPHER W. COATES

New York Aquarium
New York Zoological Society

REVISED CLASSIC

An Introduction to Mathematics. A. N. Whitehead. (First published in 1911. 12th impression. First American ed., revised and reset, 1948.) v + 191 pp. $2.00. Oxford Univ. Press. New York.

AS THE jacket claims, "this is one of the few contemporary works that can with safety and justice be called a classic." It was originally written for the Home University Library, and was better known a third of a century ago than it is today. The revisions are limited to the redrawing of diagrams and the correction of "a few inaccuracies and typographical errors . . . , but in no instance has the author's original wording been altered." It may be noted that not all the desirable corrections have been made. To cite only one of several, Abel is assigned to Sweden, which will not be exactly pleasing to Abel's compatriots. Again, the author states that "for the detailed historical facts relating to pure mathematics, I am chiefly indebted to *A Short History of Mathematics*, by W. W. R. Ball." Ball's *History* was outdated even in 1911. In the thirty-seven years since Whitehead's *Introduction* was first published, the detailed historical facts relating to pure mathematics have been radically revised.

The purpose of this classic of 1911 was to give the general reader an appreciation of the spirit of mathematics and to indicate how mathematics is applicable to natural phenomena. Some of the material is still adequate, if rather dull, but as a whole the book is hopelessly dated. The spirit of mathematics has not remained stationary in the past thirty-seven years, nor have its applications been confined to the problems of the eighteenth and nineteenth centuries. As the book has been available for over a third of a century, there is no need here to summarize its contents. In treatment it is too elementary and too sketchy for a college mathematics major in his first term, and probably too difficult for the general reader who has not thoroughly assimilated a comprehensive course in secondary-school mathematics. Need even an introduction to mathematics dwell almost exclusively on the antiquated and the obsolescent? Possibly; but it seems a pity that this first American edition of Whitehead's popular classic was not drastically revised and amplified in the spirit of 1948.

Before turning to philosophy as his major interest, Whitehead did much memorable work in mathematics, both pure and applied. It is interesting to observe the changing cast of his thought in this book, written when he was about to abandon mathematics. Prophetically—when some passages in his later writings are recalled—he observes (p. 170) that "It is a safe rule to apply that, when a mathematical or philosophical author writes with a misty profundity, he is talking nonsense." Ipse dixit.

E. T. BELL

California Institute of Technology

CORRESPONDENCE

AESTHETIC

In thumbing through my husband's copies of THE SCIENTIFIC MONTHLY, I have been both intrigued and delighted by the rare appearance of exceptionally fine poetry. It all possesses both vigor and beauty, and I feel is the one thing that completely rounds out your magazine, giving it the aesthetic touch, or a touch of the "science of the beautiful," in contrast to what, in most minds, are the great obscurities. We delighted in "The Copperhead" and "Telescope on Mount Palomar," to mention only two.

MRS. T. D. URBAHNS

Live Oak, California

USEFUL

The article by M. K. Bennett, "Population and Food Supply: The Current Scare" (January 1949), has recently been brought to my attention as representing an authoritative statement on the subject, counteracting some of the less well-founded opinions being expressed by some writers.

It is my hope to present in a course in Food Economics, which I am currently teaching, a number of the viewpoints held today on this problem, and I feel that Dr. Bennett's article would make an excellent contribution in this regard.

ODIN WILHELMY, JR.

Department of Agricultural Economics
Cornell University

SCIENCE AND TECHNOLOGY

Relative to your press release item on Snow-melting Highway in the January 1949 issue, I am sending you a clipping from *The Detroit News* (February 4, 1949, p. 40) which might interest you. The 500-foot strips of highway mentioned here are heated by electricity:

> FOR $100 YOU CAN HAVE A SNOWLESS WALK
>
> "Householders can look forward to ice-free sidewalks and driveways all year for about $100 annually, and the average store owner can expect to forget about ice and snow on his sidewalk for $50 a year.
>
> "These are the figures Harold Wall, assistant superintendent of the Public Lighting System, says it would take to heat the walks with radiant heat on the basis of the experiment with Michigan's 'warm highway' on Eight Mile road between Livernois and Wyoming avenues.
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> "For an average of $250 each for the two 500-foot strips all of the snow that has fallen on them since they were constructed in November has been melted, Wall said. That will make the annual cost of heating the highway about twice the cost of lighting the same area, he said.
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> "'A storeowner with a sidewalk 20 feet long and six feet wide could keep the walk clear of ice for $50, based on the rate for heating the highway,' Wall said.
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> "'The sidewalk in front of the average home and a track on a 100-foot driveway could be heated for $100 a year,' he added."

GEO. P. LOWEKE

Wayne University

FEDERALESE

In the contest to translate English into Federal Prose, first prize, a coat of arms showing a stuffed bureaucrat rampant on a bound volume of the *Congressional Record*, the gift package, neatly done up in red tape, goes to Ellwood H. McClelland, who has just retired from the Carnegie Library of Pittsburgh. He has translated "A rolling stone gathers no moss," and, for conciseness, has held it to one sentence:

"A detached fragment of the terrestrial lithosphere, whether of igneous, sedimentary, or metamorphic origin, and whether acquiring its approximation to sphericity through hydraulic action or other attrition, when continuously maintained in motion by reason of the instrumentality of gravitational forces constantly acting to lower its center of gravity, thus resulting in a rotational movement around its temporary axis and with its velocity accelerated by any increase in the angle of declivity, is, because of abrasive action produced by the incessant but irregular contact between its periphery and the contiguous terrain, effectively prevented from accumulating on its external surface any appreciable modicum of the cryptogamous vegetation normally propagated in umbrageous situations under optimum conditions of undeviating atmospheric humidity, solar radiation, quiescence, and comparative sequestration from erosive agencies."—*The Pleasures of Publishing,* issued semimonthly by Columbia University Press.

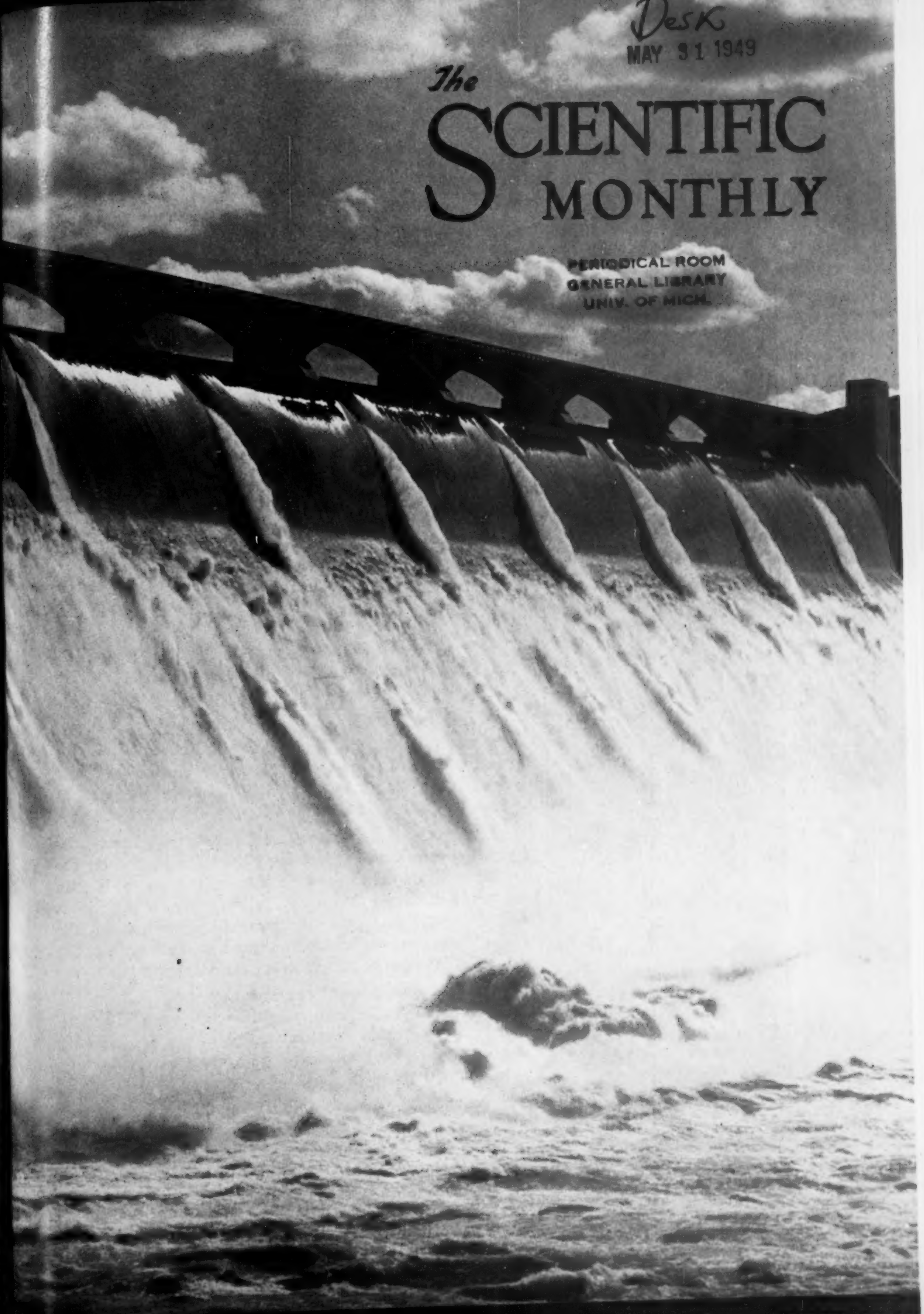
LIFE CYCLE

Biosis
Meiosis
Zygosis
Mitosis
Morphosis
Eclosis
Heterosis
Macrosis
Adiposis
Pediculosis
Psychosis
Diagnosis
Thrombosis
Sclerosis
Prognosis
Necrosis

JULIAN D. CORRINGTON

University of Miami

The SCIENTIFIC MONTHLY



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Thrombosis
Sclerosis
Prognosis
Necrosis

JULIAN D. CORRINGTON
University of Miami

New Books Received

Animals without Backbones. (Rev. ed.) RALPH BUCHSBAUM. xii + 405 pp. Illus. $6.50. Univ. of Chicago Press. 1948.

Sweeper in the Sky. HELEN WRIGHT. vii + 253 pp. $4.00. Macmillan. New York. 1949.

The Failure of Technology: Perfection without Purpose. FREIDRICH GEORG JUENGER. x + 186 pp. $2.75. Henry Regnery. Hinsdale, Ill. 1949.

Geology and Origin of South Park, Colorado. VARIOUS EDITORS. Memoir 33. viii + 188 pp. Map pocket. Illus. Geol. Soc. New York. 1949.

A Brief Biology. JAMES WATT MAVOR. viii + 427 pp. Illus. $4.00. Macmillan. New York. 1949.

Studies in Analytical Psychology. GERHARD ADLER. 250 pp. Illus. $4.00. Norton. New York. 1948.

Readings in the Clinical Method in Psychology. ROBERT I. WATSON. xi + 740 pp. $4.50. Harper. New York. 1949.

Roots of Political Behavior: Introduction to Government and Politics. RICHARD CARLTON SNYDER and H. HUBERT WILSON, Eds. ix + 694 pp. $5.25. American Book Co. New York. 1949.

The Structure of Matter. FRANCIS OWEN RICE and EDWARD TELLER. xiii + 361 pp. Illus. $5.00. Wiley. New York. 1949.

An Introduction to Comparative Biochemistry. ERNEST BALDWIN. xiii + 164 pp. Illus. $1.75. Cambridge Univ. Press. New York. 1948.

Tropical Birds. From Plates by JOHN GOULD. Introduction by SACHEVERELL SITWELL. 12 pp. 16 plates. $2.00. Batsford. New York. 1948.

Engineering the New Age. JOHN J. O'NEILL. 320 pp. $3.50. Ives Washburn. New York. 1949.

Child Psychiatry. (2nd ed.) LEO KANNER. xxiv + 752 pp. $8.50. Charles C Thomas. Springfield, Ill.

Discoverers for Medicine. WILLIAM WOGLOM. 229 pp. Illus. $3.75. Yale Univ. Press. 1949.

Drug Plants of Africa. (African Handbooks: 8) THOMAS S. GITHENS. vii + 125 pp. $2.25. Univ. of Pennsylvania Press. 1948.

The Parasitic Cuckoos of Africa. HERBERT FRIEDMANN. xii + 204 pp. Illus. $4.50. Washington (D. C.) Academy of Sciences. 1948.

Gustavus Sohon's Portraits of Flathead and Pend D' Oreille Indians, 1854. JOHN C. EWERS. 68 pp. 22 plates. Smithsonian Institution. Washington, D. C. 1948.

Human Behavior and the Principle of Least Effort. GEORGE KINGSLEY ZIPF. xi + 573 pp. Illus. $6.50. Addison-Wesley Press. Cambridge, Mass. 1949.

Microfilm Abstracts. Vol. VIII, No. 2. EUGENE POWER, Ed. xiii + 190 pp. University Microfilms. Ann Arbor, Mich. 1948.

Sedimentary Rocks. F. J. PETTIJOHN. xv + 526 pp. Illus. $7.50. Harper. New York. 1949.

Permian Crinoid Calceolispongia. CURT TEICHERT. x + 132 pp. Illus. Geol. Soc. New York. 1949.

Atomic Energy Development, 1947–1948. U. S. ATOMIC ENERGY COMMISSION. 213 pp. Illus. 45 cents. U. S. Govt. Printing Office. Washington, D. C. 1949.

Archibald Henderson: The New Crichton. SAMUEL STEVENS HOOD, Ed. xviii + 253 pp. Illus. $5.00. Beechhurst Press. New York. 1949.

Thyroid Function as Disclosed by Newer Methods of Study. VARIOUS AUTHORS. 229 pp. Illus. $3.00. Annals N. Y. Acad. of Sciences. 1949.

Doctors of Infamy: The Story of the Nazi Medical Crimes. ALEXANDER MITSCHERLICH. xxxix + 172 pp. Illus. $3.00. Schuman. New York. 1949.

The Origin of Genius. ALFRED HOCK. JOHN GUTMAN, Trans. 62 pp. Pub. by the Author, 105 Murray St., Binghamton, N. Y. 1949.

The Biological Station of the Ohio State University. THOMAS H. LANGLOIS. vii + 64 pp. Ohio State Univ. 1949.

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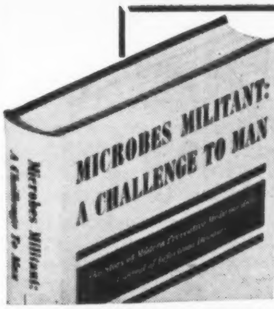

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Meetings

May 2. American Society for Clinical Investigation (Annual, National). Haddon Hall, Atlantic City.

May 2–3. Southern Association of Science and Industry. Washington and Lee University, Lexington, Va.

May 2–4. Forest Research Products Society. (Annual, National). Civic Auditorium, Grand Rapids, Mich.

May 2–13. British Industries Fair. Earl's Court and Olympia, London; Castle Bromwich, Birmingham.

May 4–7. Electrochemical Society (Semiannual). Ben Franklin Hotel, Philadelphia.

May 6–7. American Institute of Chemists. Edgewater Beach Hotel, Chicago.

May 6–7. American Council on Education (Annual). Mayflower Hotel, Washington, D. C.

May 9–11. Liquefied Petroleum Gas Association. Palmer House, Chicago.

May 9–12. American Oil Chemists' Society (Annual). Hotel Roosevelt, New Orleans.

May 12–13. Instrument Society of America (Annual). Royal York Hotel, Toronto.

May 16–20. American Association of Cereal Chemists (Annual). Hotel Statler, New York.

May 16–20. Society of American Bacteriologists (Annual). Cincinnati.

May 17–20. Fifth International Congress for Comparative Pathology. Istanbul.

May 19–21. Armed Forces Chemical Association (Annual). Army Chemical Center, Md.

May 22–27. American Psychiatric Association (Annual). Windsor Hotel, Montreal.

May 26–27. Natural Gas and Petroleum Association of Canada (Annual). Hotel London, London, Ont.

May 20–27. Society of the Plastics Industry (Annual). Edgewater Beach Hotel, Chicago.

May 20–June 1. Chemical Institute of Canada. Halifax, N. S.

June 15. American Society of Mammalogists (Annual). Washington, D. C.

June 20–25. International Conference on "Science Abstracting" (UNESCO). Paris.

June 21–23. American Dairy Science Association (Annual). University of Minnesota, St. Paul.

Aug. 15–19. International Dairy Congress, Stockholm.

Aug. 17–Sept. 6. United Nations Scientific Conference. Lake Success.

Aug. 23–26. American Institute of Electrical Engineers (1949 Pacific). Fairmont Hotel, San Francisco.

Sept. 5–10. American Psychological Association. Hotel Shirley-Savoy, Denver.

Sept. 6–10. General Conference, International Union of Pure and Applied Chemistry. Amsterdam.

Sept. 14–16. General Assembly, International Council of Scientific Unions. Copenhagen.

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